

Section 2 Kewalo Geographic Zone (T-162 to T-178)

2.1 Overall Location

For reporting purposes for this AIS, the City Center Section 4 of the HHCTCP has been divided into 11 zones based on geographical and cultural boundaries. The Kewalo Geographic Zone was located within the eastern portion of Honolulu Ahupua'a, Honolulu District, Island of O'ahu, in a physiographic division known as the Honolulu Plain (Armstrong 1983:36). The Kewalo portion of the City Center Section 4 route extends approximately 460 m from Ward Avenue at Halekauwila Street on the west arcing slightly north (*mauka*) to continue east along the *makai* side of Queen Street (Figure 109). As part of the City Center AIS, a total of 24 test excavations (T-162 through T-178, T-168A, T-168B, T-170A, T-172A, T-174A, T-175A, and T-178A) were excavated in the Kewalo Zone between Halekauwila Street and Kamake'e Street.

While this portion of the route crosses City and County property at Ward Avenue, all of the Kewalo Zone test excavations were on private lands with T-162 through T-169, T-168A, and T-168B located within TMK [1] 2-3-002:059 and T-170 through T-177, T-170A, T-172A, T-174A, T-175A, and T-178A located within TMK [1] 2-3-002:001 (owned by Victoria Ward, Ltd.) and T-178 located within TMK [1] 2-3-003:087 (owned by the Hawaii Community Development Authority).

2.2 Geography, Geology, and Land Forms

The Kewalo Zone was situated along the low-lying coastal flats immediately inland of present day Kewalo Basin (approximately 500 m inland from the natural coastline at the edge of today's Ala Moana Boulevard) and was relatively flat. The Kewalo Zone consists of a portion of the broad elevated coral reef in southern Oahu that probably formed during the 7.5-m (Waimanalo) stand (Macdonald et al. 1983:420-421). Present day elevations in the zone range from approximately 1.3 m to 2.2 m above mean sea level. Early maps indicate that the vicinity of the Kewalo Zone was a little higher than the extensive marshes to the northwest. It seems probable that the Kewalo Zone occupied a low coastal dune that was a factor in backing up this shallow marsh.

The average annual rainfall measures 663 to 679 mm (26 to 27 inches) (Giambelluca et al. 2011), which would be marginal at best for non-irrigated agriculture. There were no perennial streams between Nu'uanu Stream 2 km to the west and the former Pi'inaio Stream (that ran roughly north/south (*mauka/makai*) along the present eastern portion of Ala Moana Boulevard before debouching near the present Ala Wai Boat Harbor) approximately 1.5 km to the east. Kanaha Stream originating in Makiki Valley meandered and dissipated through the marshy Makiki coastal lands. Kewalo was well-known for freshwater springs, as seen in the proverb "*Ka wai huahua 'i o Kewalo*," which translates as "The bubbling water of Kewalo." There were also a number of medium-sized fishponds to the northeast and northwest.

Native vegetation in this area was not well documented, but just prior to development in the early twentieth century was understood as including *naupaka* (*Scaevola taccada*), *keawe* (*Prosopis pallida*), and coconut (*Cocos nucifera*). Today, virtually all vegetation was the result of landscaping efforts.

According to the U.S. Department of Agriculture Soil Survey Geographic (SSURGO) Database (2001) and soil survey data gathered by Foote et al. (1972), soils within the Kewalo Zone consist exclusively of Fill Land (FL) (Figure 109). Fill Land soils were described as:

...areas filled with material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources... This land type was used for urban development including airports, housing areas, and industrial facilities [Foote et al. 1972:31].

The topography in the vicinity was relatively featureless. There was a particularly pronounced channel through the reef (resulting from an ancient alignment of Kanaha Stream) that was later developed for Kewalo Basin that was probably a significant focus for canoe anchorage and fishing expeditions (as it remains today).

2.3 Modern Land Use and Built Environment

The Kewalo Zone traverses an urban environment through the neighborhood of Kaka'ako/Kewalo. The Kewalo Zone corridor begins near the intersection of Halekauwila Street and Ward Avenue at the northwest end and cuts across current parking lots and commercial structures to get to and then follow along the *makai* side of Queen Street to Kamake'e Street at the southeast end. Parcels bordering the Kewalo Zone corridor contain commercial buildings and warehouses and large parking lots. A massive utility corridor was also present throughout the Kewalo Zone containing electrical, gas, water, sewer, and storm lines. The number and distribution of these existing utilities indicate that this portion of the transit corridor has been heavily disturbed in the past

2.4 GPR Sediment Summary

Test excavations in the Kewalo Geographic Zone (Zone 8) revealed that the area was predominantly Fill Lands (FL) as predicted by the U.S.G.S Soil survey map of the zone (Figure 109). Naturally deposited sediments encountered in this zone were generally too deep for the GPR to clearly read. The average depth of clean signal return for this area was approximately one m. Test Excavations that contained naturally deposited sediments within the GPR clean signal range were included in Table 2. Naturally deposited sediments within the range of clean GPR signal return for Zone 8 Representative signal texture profiles for Zone 8 were shown in Figure 110 Signal texture profiles were only collected if the signal return was clear and the stratum was at least 0.25 m thick.

Table 2. Naturally deposited sediments within the range of clean GPR signal return for Zone 8

ZONE 8-KEWALO (T-162 TO T-178)			
TEST EXCAVATION	STRATUM	MATERIAL	STRATUM ORIGIN (mbs)
170	II	silty sand	0.5
170	III	sand	0.7
170	IV	loamy sand	1.0
170A	II	silty coarse sand	0.45
170A	III	coarse sand	0.6
174	II	sand	0.8
174	III	sandy loam	0.8
175	II	sand	0.7
175	III	sand	0.7
176	II	loamy sand	0.4

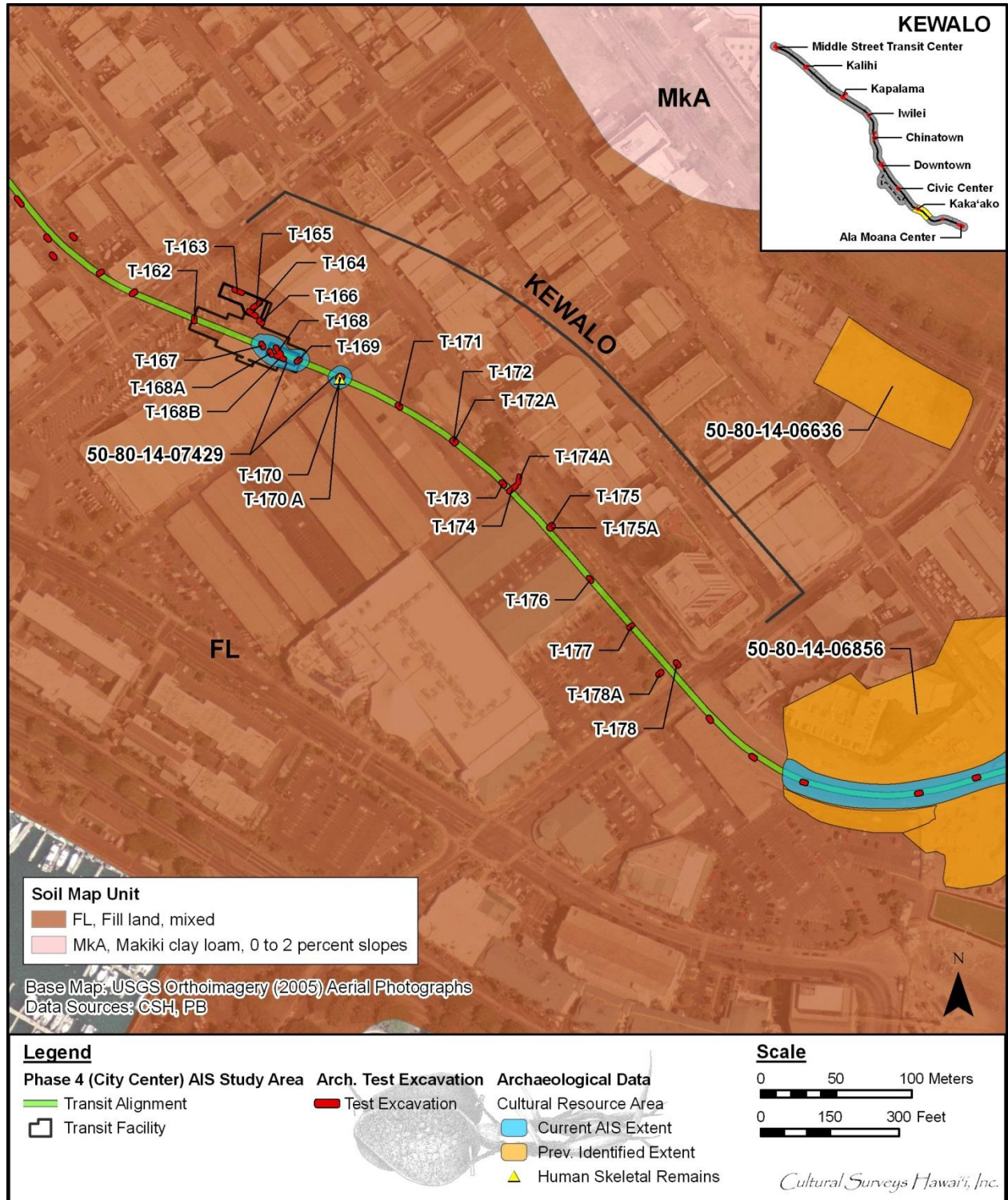


Figure 109. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005) with overlay of the Soil Survey of Hawai'i (Foote et al. 1972) showing sediment types within and in the vicinity of the Kewalo Zone

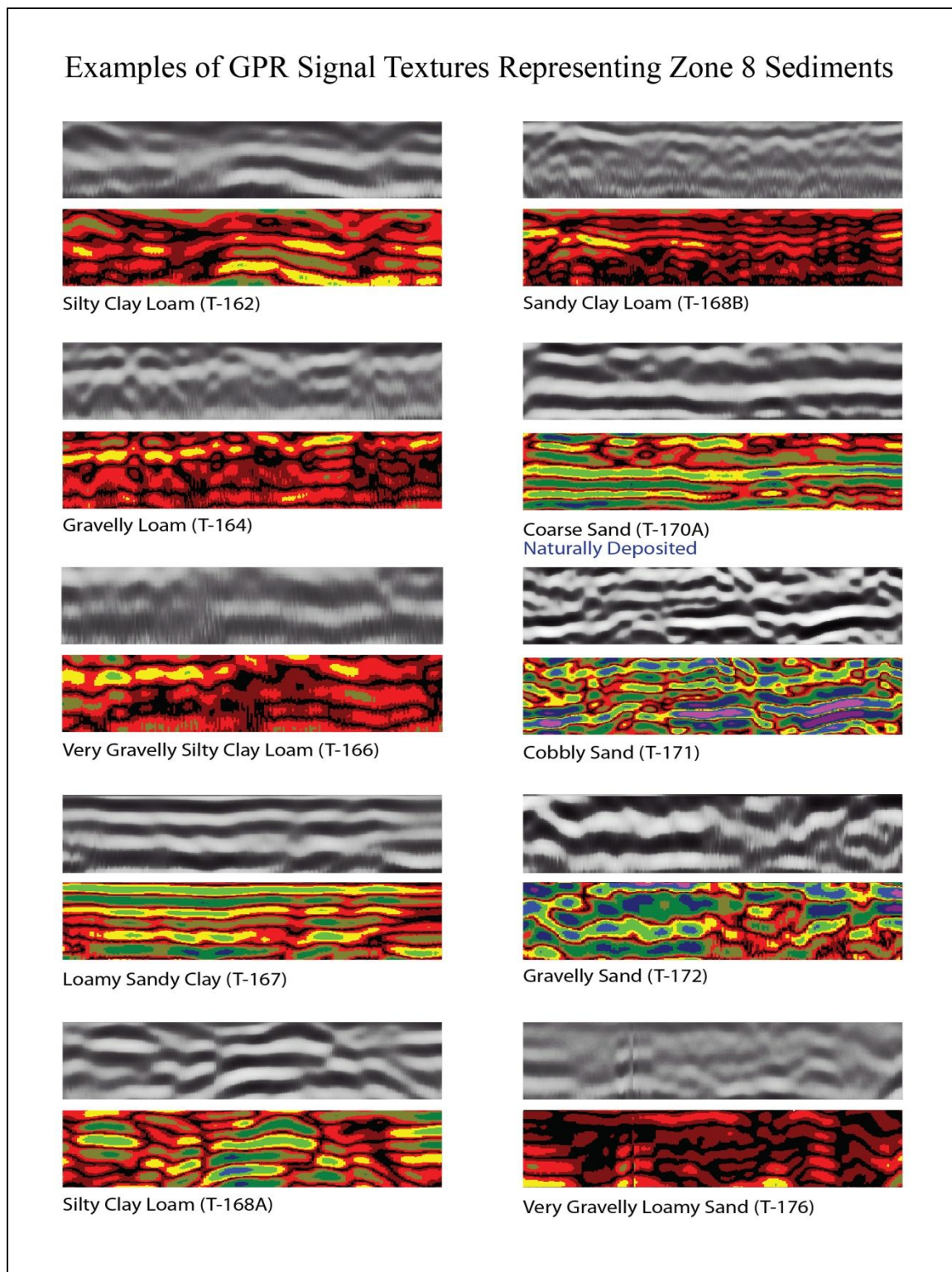


Figure 110. Examples of GPR signal textures representing Zone 8 sediments

Test Excavation 162

T-162 measured 0.9 m by 3.0 m and was oriented north to south and was located within Ross Dress For Less parking lot, 47.0 m east of Halekauwila Street and Ward Avenue intersection. The GPR grid measured 2.5 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, no utilities were located near the excavation location. A cast iron utility pipe was encountered 1.0 mbs and was oriented diagonally across the northern end of the excavation.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 111).

GPR depth profiles for T-162 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 112). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. An anomaly was observed in the profile that could corresponded to the utility encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

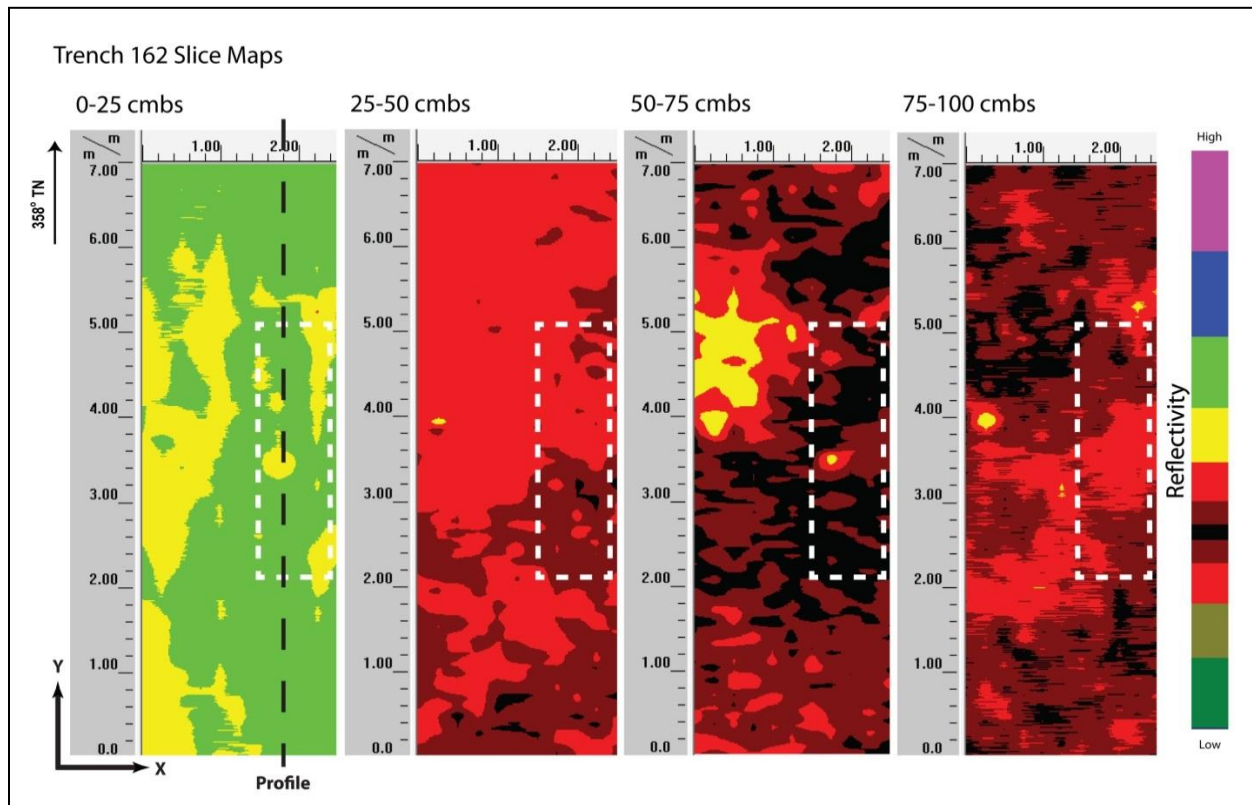


Figure 111. Slice maps of T-162 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 112). Strata Ia to Id were clearly observed and occurred at the ground-truthed depths. A cast iron utility pipe was found 1.0 mbs. This corresponded with a small anomaly at this location on the profile map, but it was very difficult to interpret as such. The lack of a clean hyperbola may be a result of the pipe being empty. No other discrete objects were observed in the GPR results or subsequent excavation.

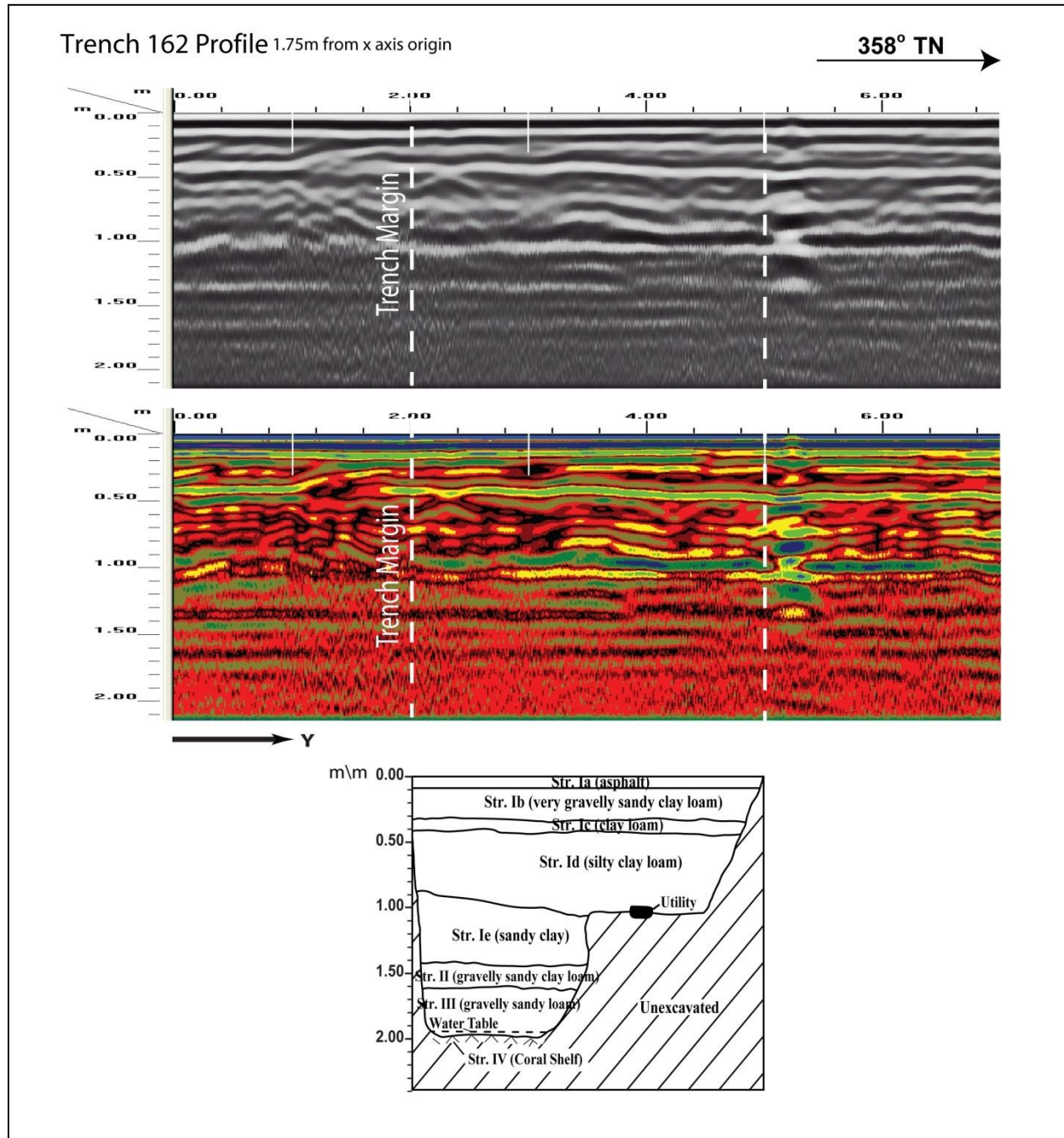


Figure 112. Visual comparison of excavated profile and GPR signal profile of T-162

Test Excavation 163

T-163 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the Ross Dress For Less parking lot, 32.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 2.5 m by 8.0 m with 2.05 cm spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity to the excavation. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 113).

GPR depth profiles for T-163 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 114). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.35 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.9 mbs.

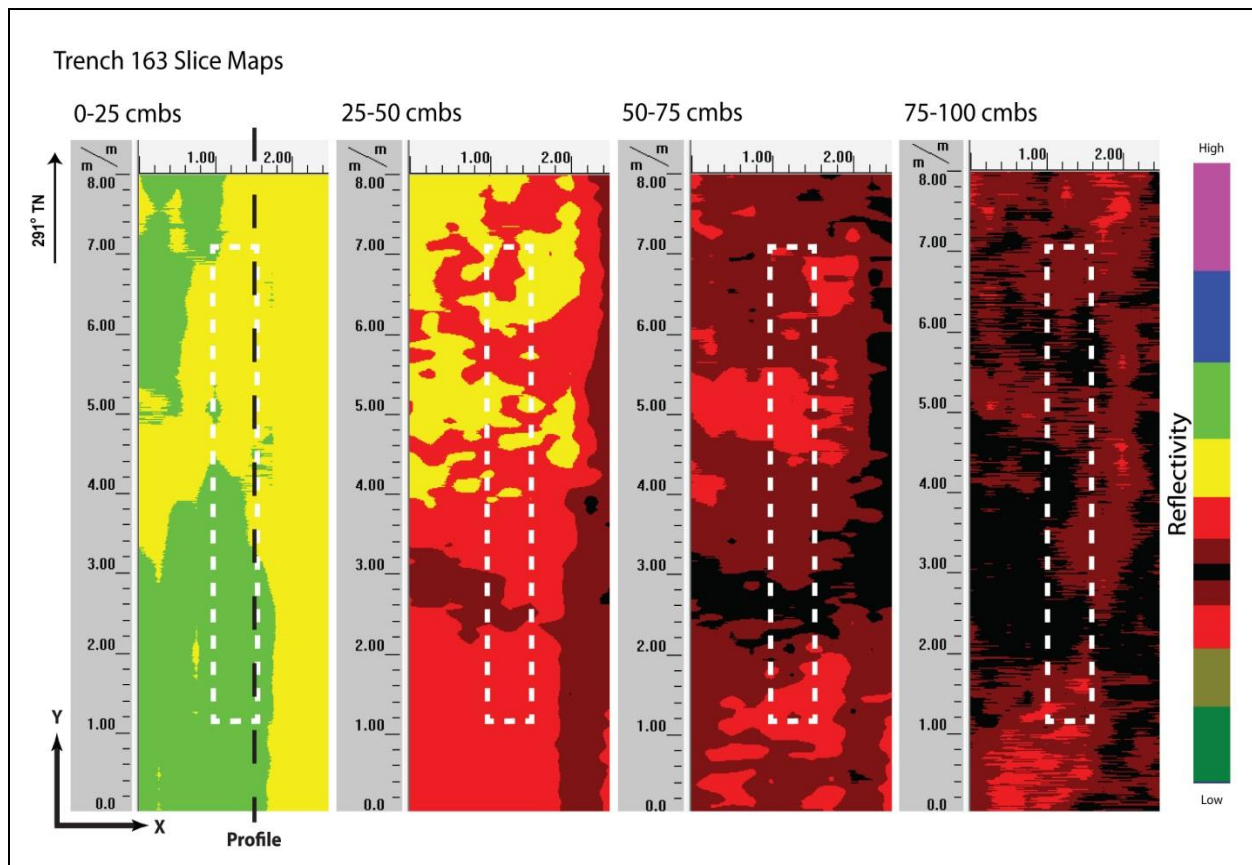


Figure 113. Slice maps of T-163 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 114). Strata Ia to Ie were all clearly observed and occurred near the ground-truthed depths. The strata may be difficult to individually discern, due to the fact that they were thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

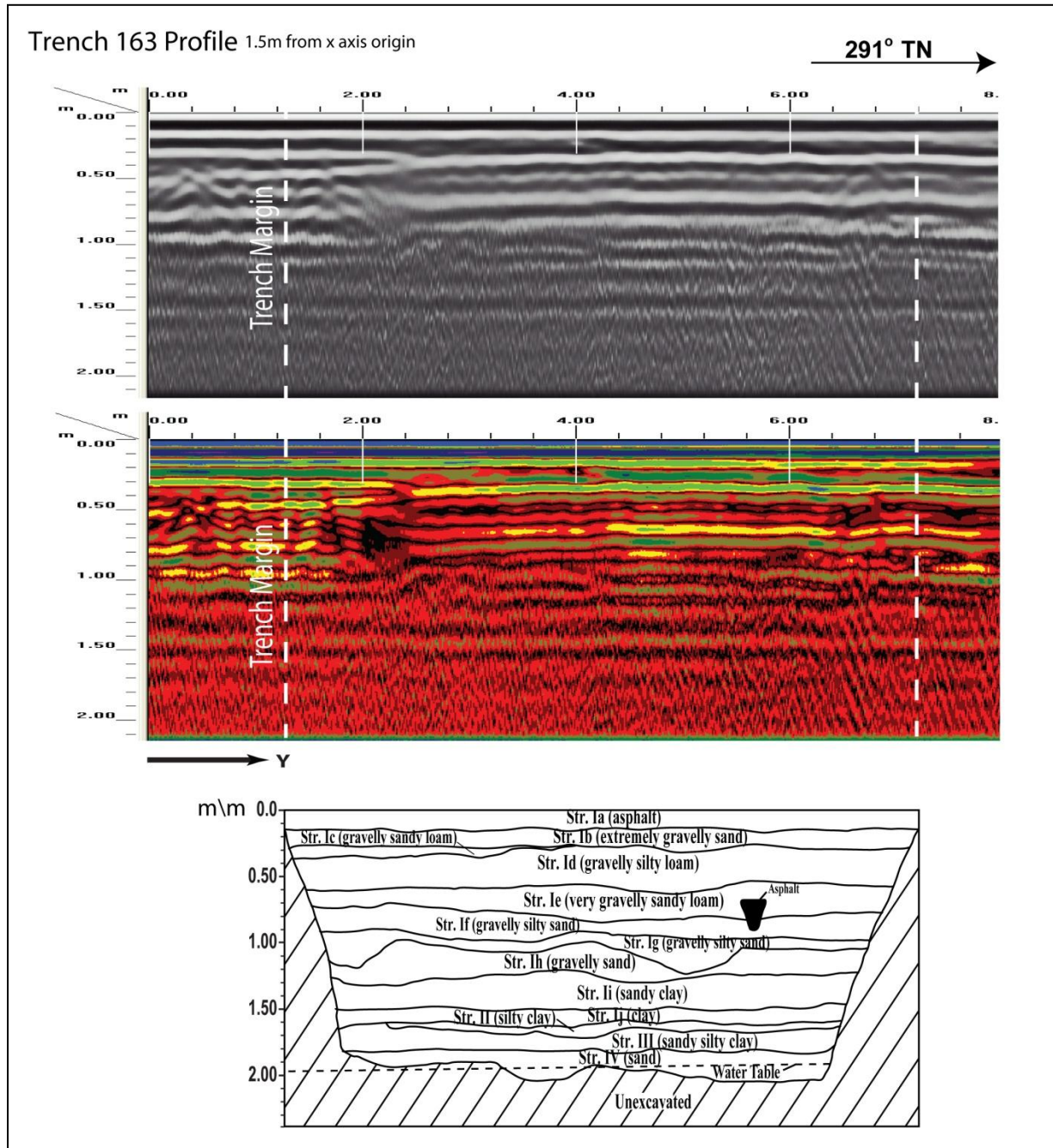


Figure 114. Visual comparison of excavated profile and GPR signal profile of T-163

Test Excavation 164

T-164 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the Ross Dress For Less parking lot, 50.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity to the excavation. A utility was encountered 1.04 mbs and within the center of the excavation.

A review of amplitude slice maps indicated no linear features although a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 115).

GPR depth profiles for T-164 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 116). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs. No utilities were observed in the profile although a utility was encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

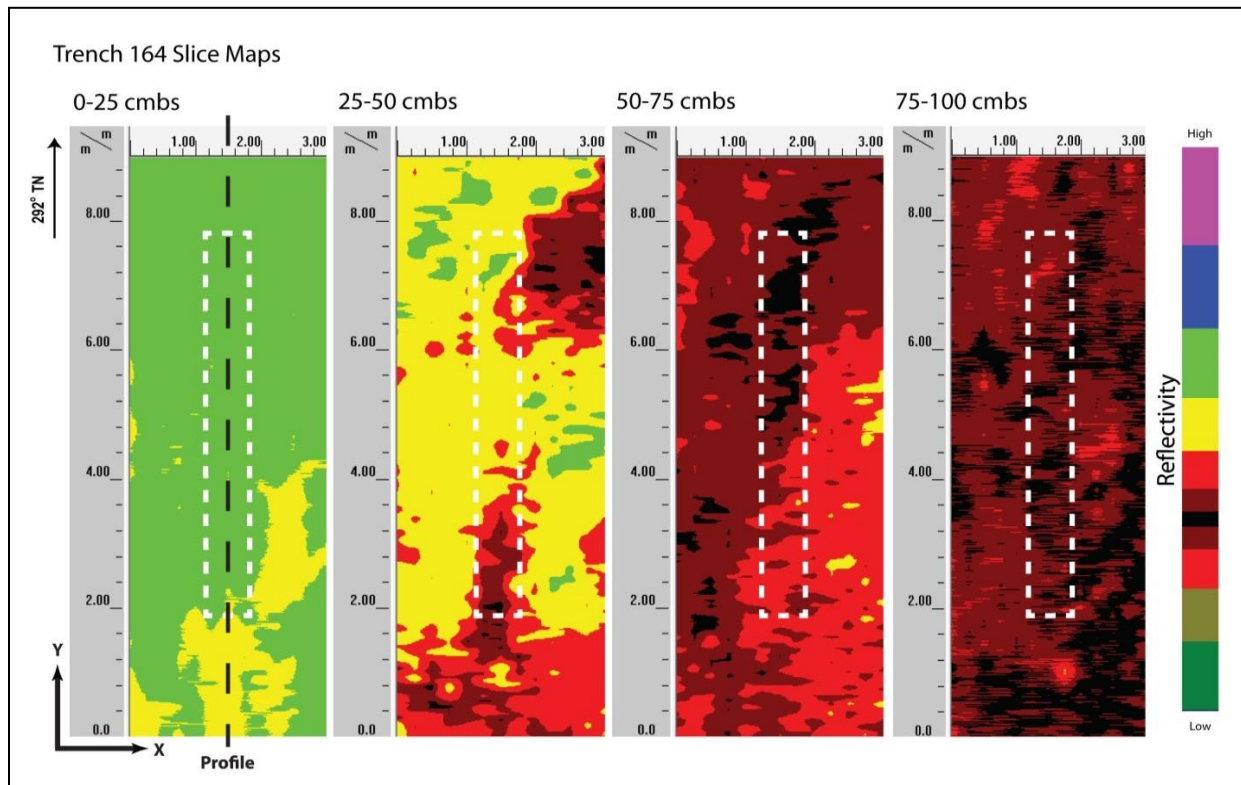


Figure 115. Slice maps of T-164 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 116). Strata Ia through Ie were clearly observed and occurred at the ground-truthed depths. Strata Ia through Id may be difficult to individually discern, possibly due to the fact that they were thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. A utility pipe was found 1.04 mbs. This pipe did not show up on the profile or slice maps because it was below the maximum clean signal return depth. No other discrete objects were observed in the GPR results or subsequent excavation.

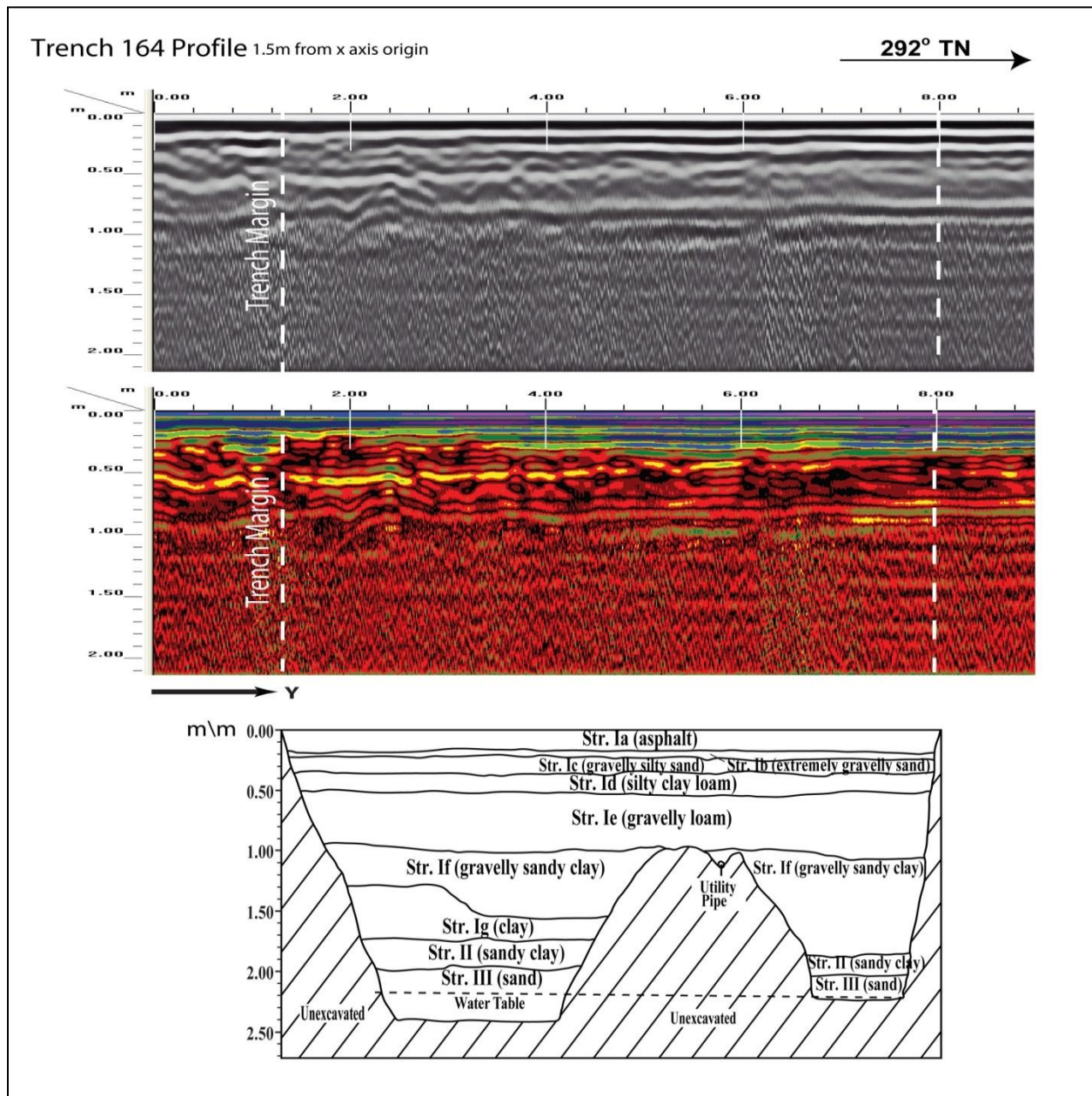


Figure 116. Visual comparison of excavated profile and GPR signal profile of T-164

Test Excavation 165

T-165 measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the Ross Dress For Less parking lot, 49.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity to the excavation. No utilities transected the excavation location.

A review of amplitude slice maps indicated a linear feature that was not encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 117).

GPR depth profiles for T-165 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 118). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. An anomaly was observed in the profile but was not encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

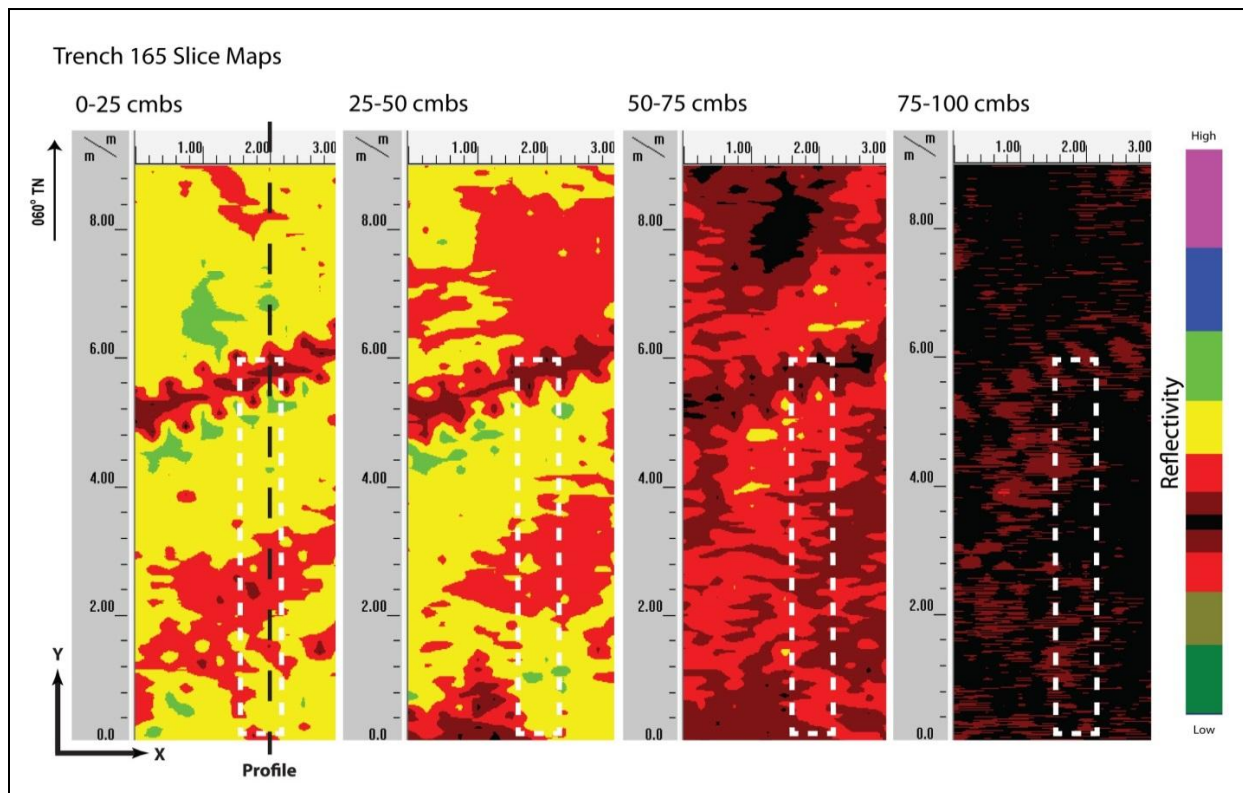


Figure 117. Slice maps of T-165 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 118). Strata Ia to Id were all clearly observed and occurred near the ground-truthed depths. Strata Ia through Id may be difficult to individually discern, possibly due to the fact that they were thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

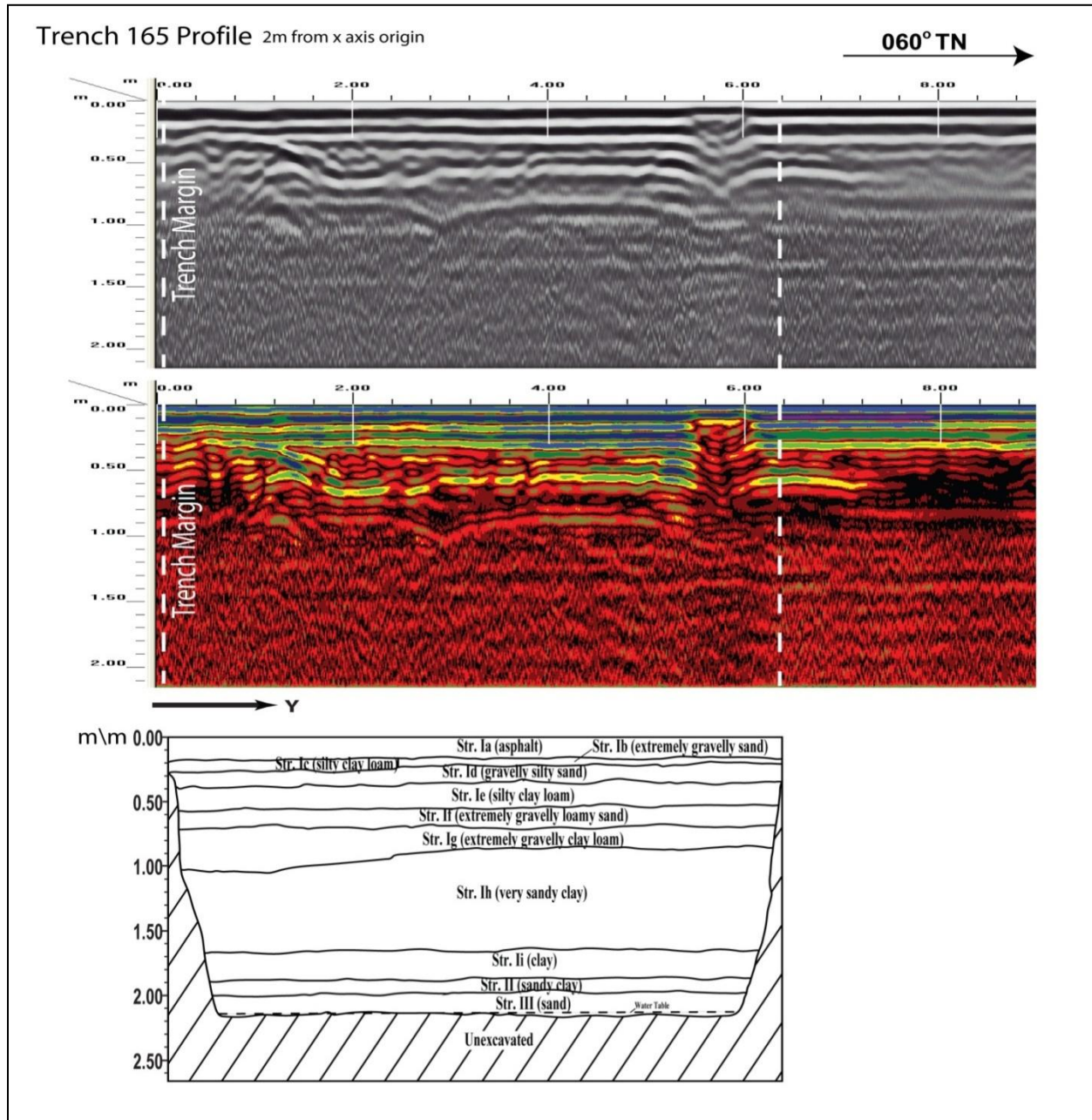


Figure 118. Visual comparison of excavated profile and GPR signal profile of T-165

Test Excavation 166

T-166 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the Ross Dress For Less parking lot, 58.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 2.5 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity to the excavation. A utility was encountered 0.53 mbs in the western end of the excavation.

A review of amplitude slice maps indicated no linear features although a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 119).

GPR depth profiles for T-166 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 120). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No utilities were observed in the profile although a utility was encountered during excavation. The maximum depth of clean signal return was approximately 0.7 mbs.

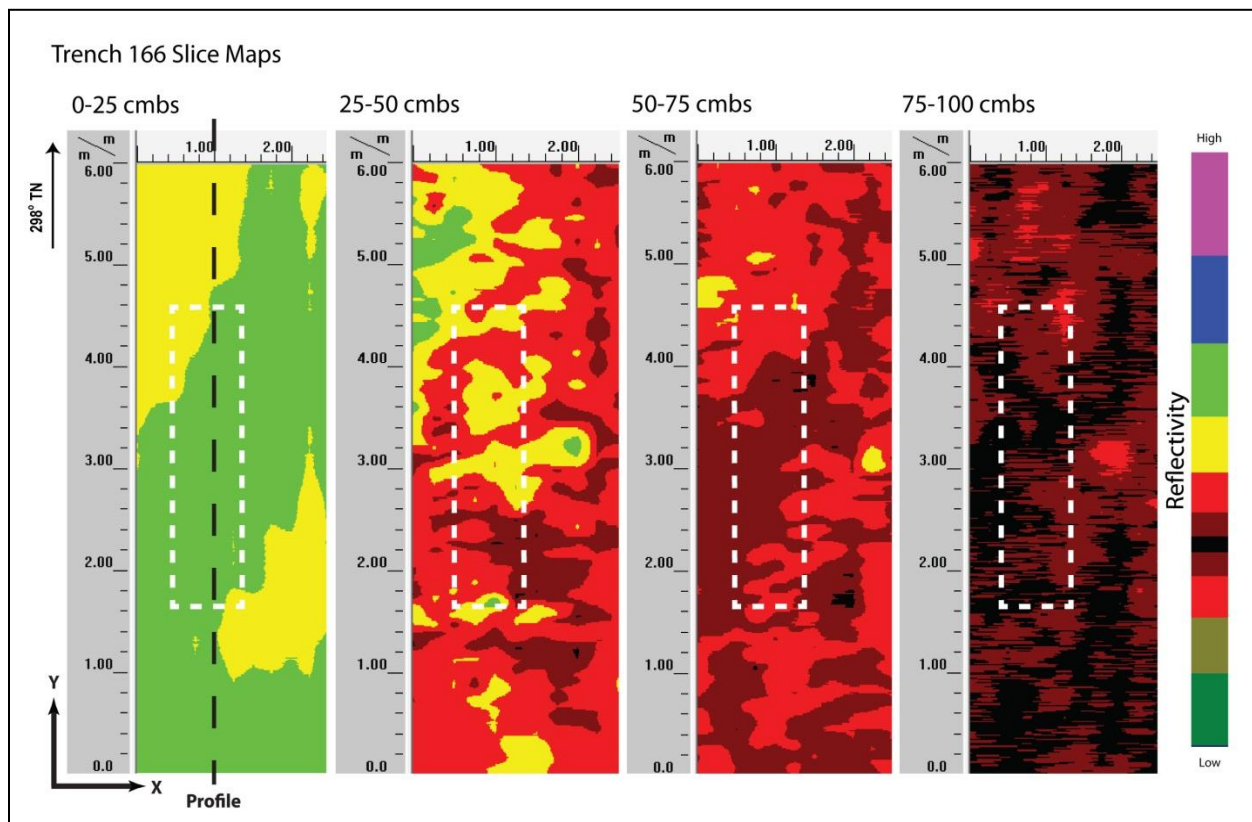


Figure 119. Slice maps of T-166 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 120). Strata Ia to Ic were all clearly observed and occurred near the ground-truthed depths. A utility pipe was found 0.53 mbs. This pipe did not show up on the profile or slice maps. This may be due to the fact that the pipe was empty or it may have had a similar density to the surrounding stratum. No discrete objects were observed in the GPR results or subsequent excavation.

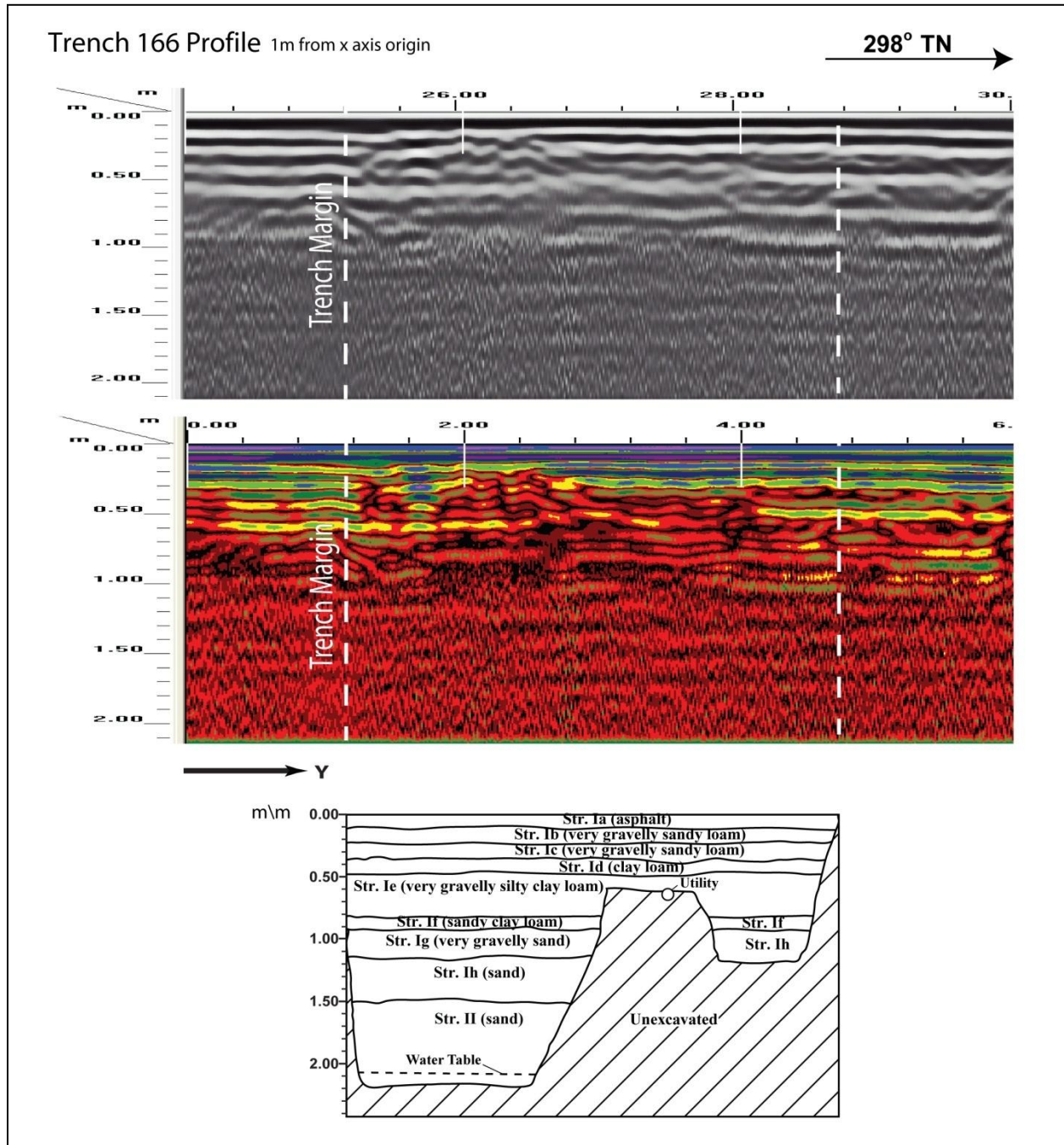


Figure 120. Visual comparison of excavated profile and GPR signal profile of T-166

Test Excavation 167

T-167 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the Ross Dress For Less parking lot, 72.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 2.25 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 0.5 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs and increases again around 0.75 mbs (Figure 121).

GPR depth profiles for T-167 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 122). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs. Anomalies were observed in the profile but were not encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

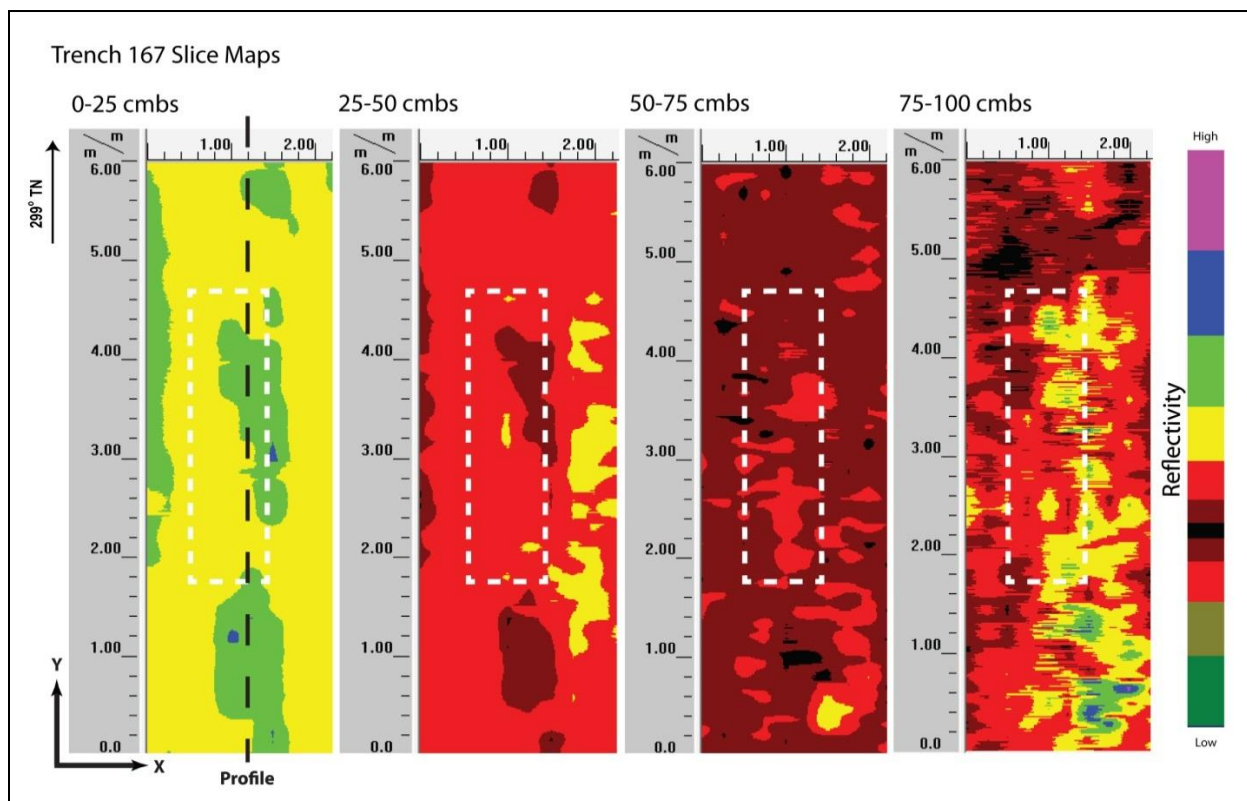


Figure 121. Slice maps of T-167 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 122). Strata Ia to Ic and Ie to Ih were all clearly observed and occurred near the ground-truthed depths. These strata may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

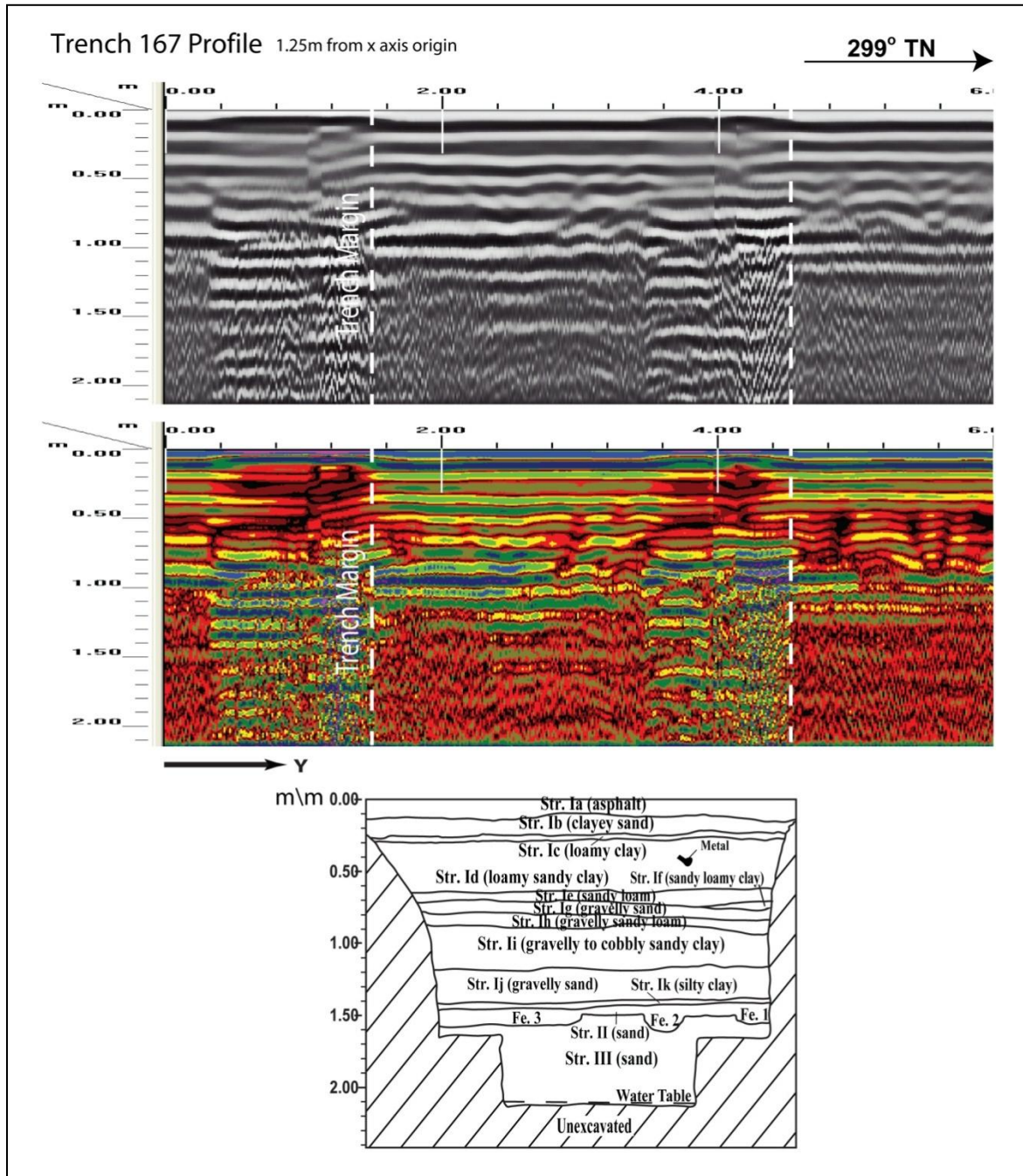


Figure 122. Visual comparison of excavated profile and GPR signal profile of T-167

Test Excavation 168

T-168 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the Ross Dress For Less parking lot, 80.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 2.5 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 6.5 m southwest, sewer line 8.0 m northeast. A metal utility pipe was encountered 1.49 mbs in the center of the excavation location.

A review of amplitude slice maps indicated no linear features although a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 123).

GPR depth profiles for T-168 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 124). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No utilities were observed in the profile however a metal pipe was encountered 1.49 mbs which was below the depth of clean signal return. The maximum depth of clean signal return was approximately 1.0 mbs.

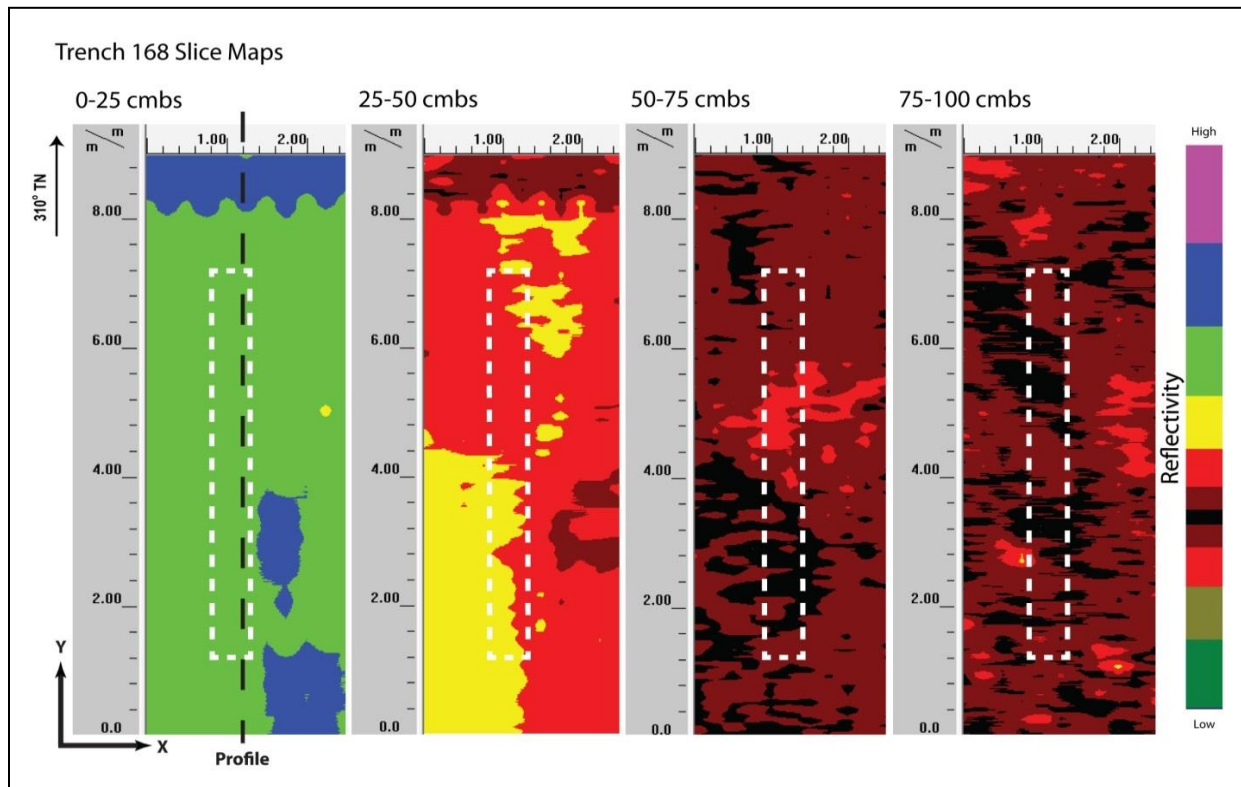


Figure 123. Slice maps of T-168 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 124). Stratum Ia was clearly observed and occurs at the ground-truthed depths. Other strata included: very gravelly clayey sand fill, gravelly sandy loam fill, very gravelly sandy loam fill, sandy clay fill, gravelly sand fill, extremely gravelly sand fill, sand fill, silty clay fill, natural loamy sand, and natural sand. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. A utility pipe was found 1.49 mbs. This pipe did not show up on the profile or slice maps because it was below the maximum clean signal return depth. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

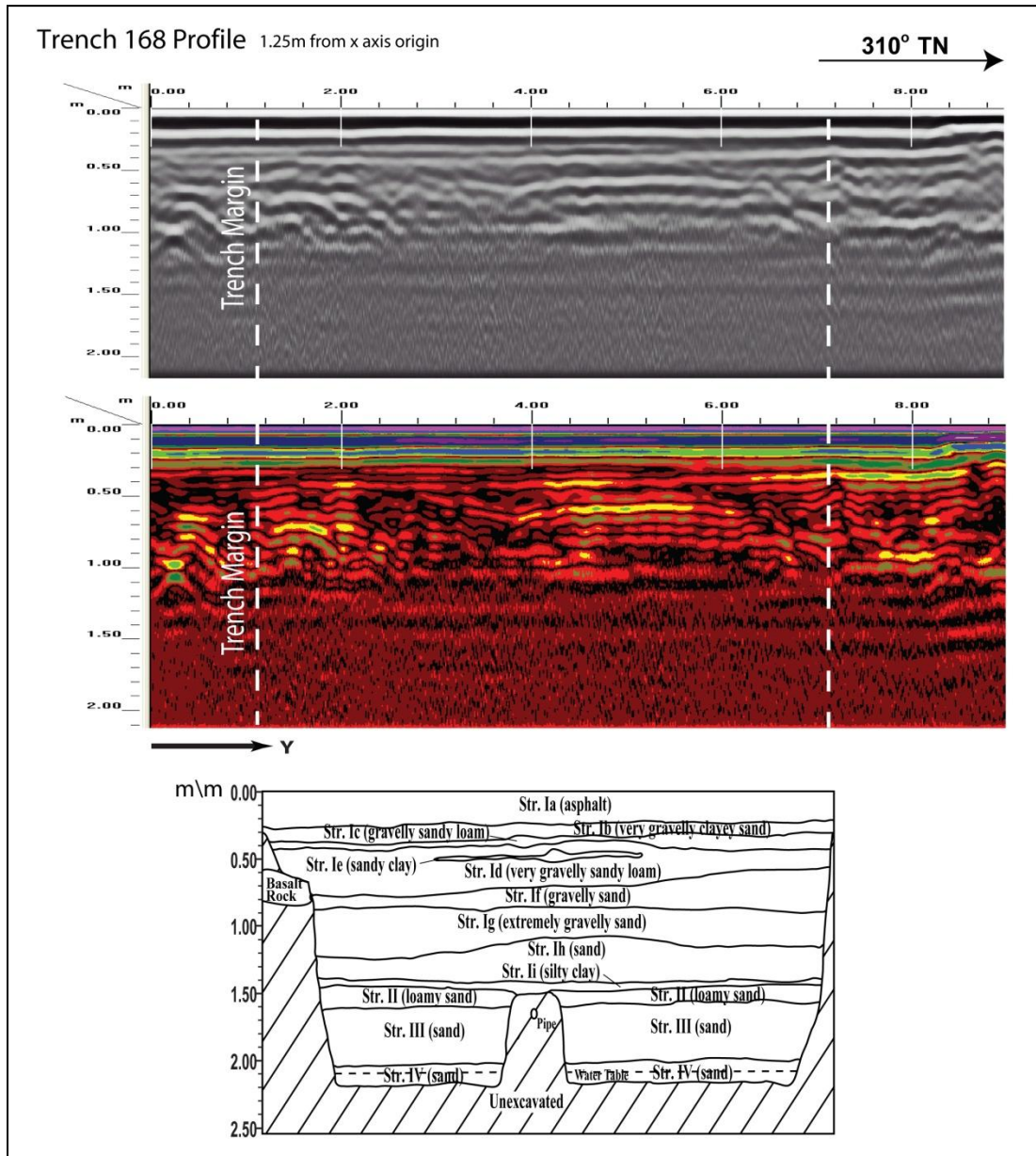


Figure 124. Visual comparison of excavated profile and GPR signal profile of T-168

Test Excavation 168A

T-168A measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the Ross Dress For Less parking lot, 79.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 3.0 m by 5.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 1.5 m northeast. A concrete slab was encountered 0.3 mbs on the northern end of excavation.

A review of amplitude slice maps indicated no linear features although a concrete jacket was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 125).

GPR depth profiles for T-168A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 126). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. No utilities were observed in the profile although a concrete utility jacket was encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

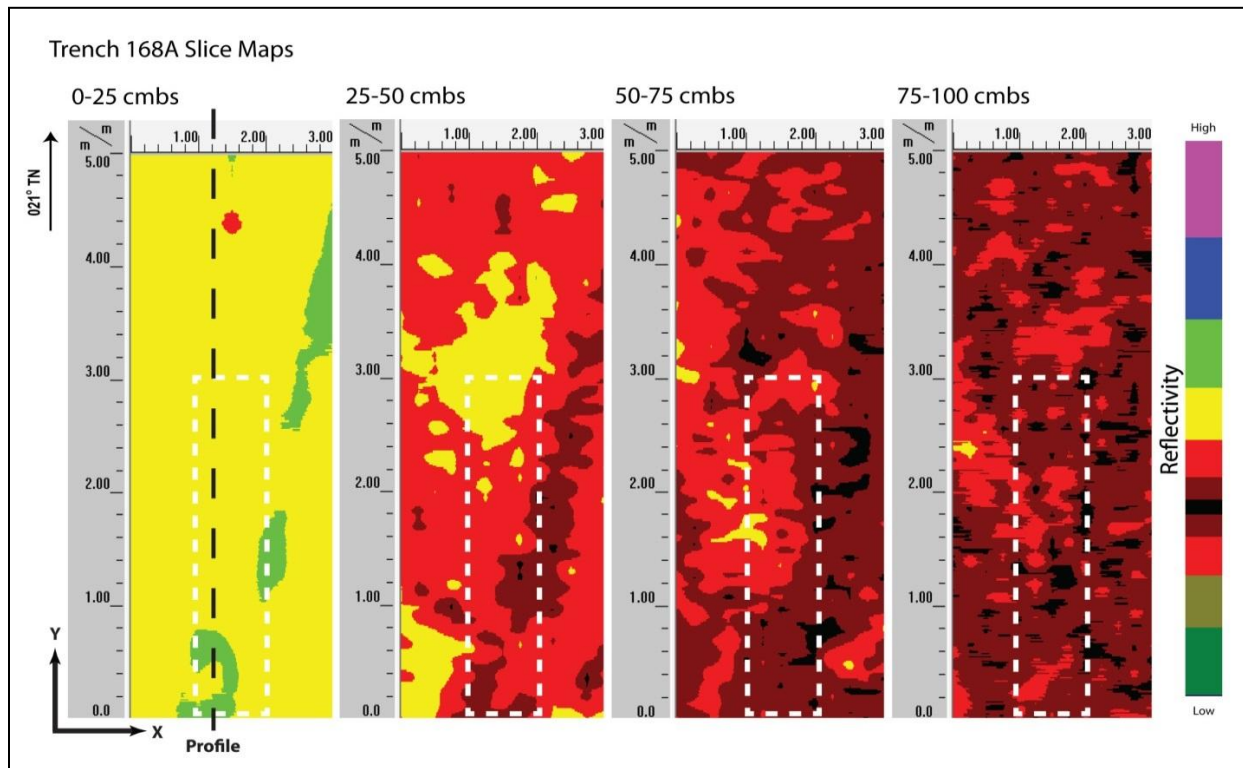


Figure 125. Slice maps of T-168A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 126). Strata Ia to Ie were all clearly observed and occurred near the ground-truthed depths. Strata Ia through Id may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. A concrete slab was found 0.3 mbs. This concrete slab did not show up on the profile or slice maps. No other discrete objects were observed in the GPR results or subsequent excavation.

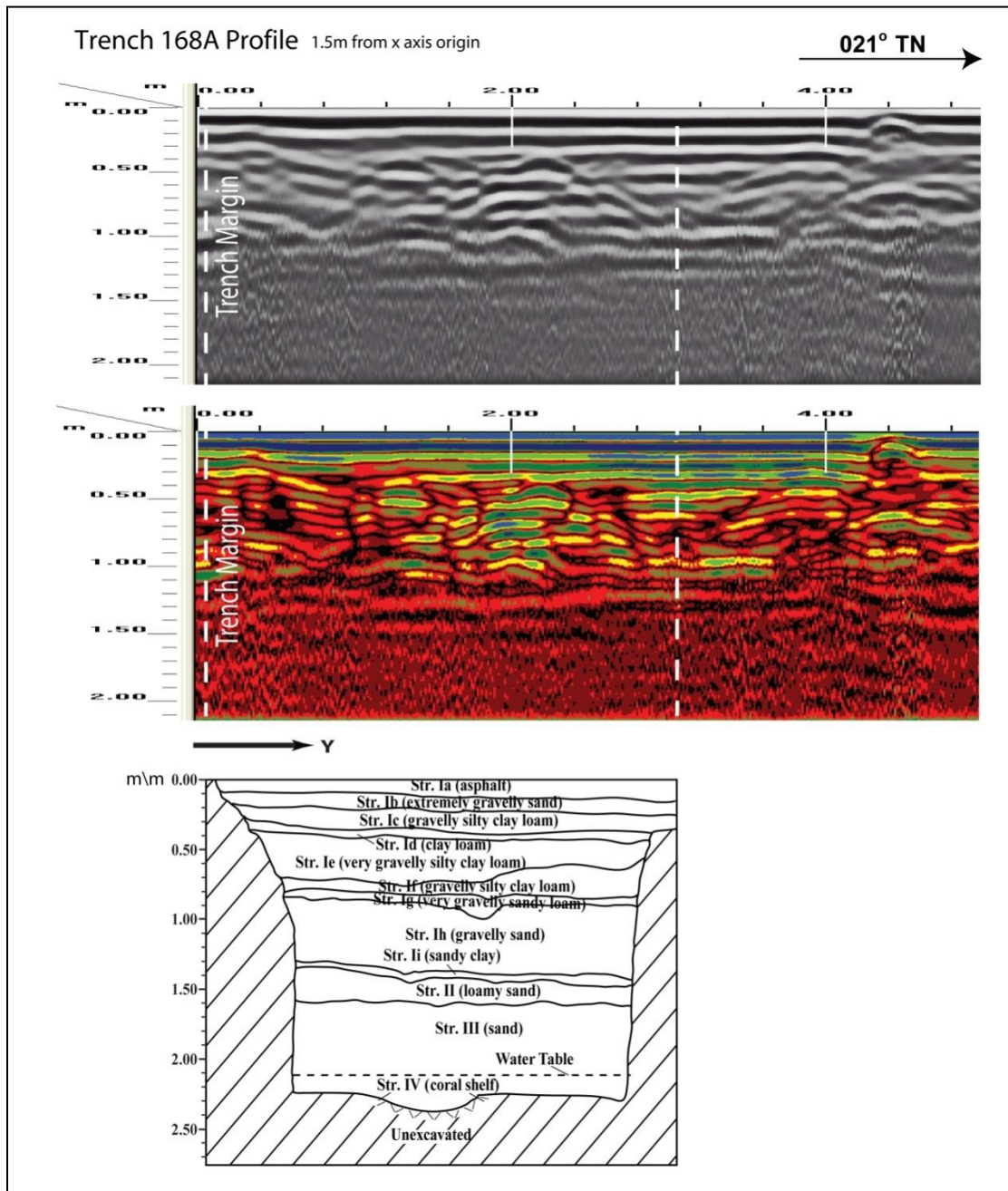


Figure 126. Visual comparison of excavated profile and GPR signal profile of T-168A

Test Excavation 168B

T-168B measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the Ross Dress For Less parking lot, 84.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 3.5 m west, sewer line 4.8 m southeast. An abandoned metal utility pipe was encountered 1.38 mbs in the center of the excavation location.

A review of amplitude slice maps indicated no linear features although an abandoned metal utility line was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 127).

GPR depth profiles for T-168B identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 128). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.35 mbs. No utilities were observed in this profile although an abandoned utility was encountered below the clean signal return. The maximum depth of clean signal return was approximately 1.0 mbs.

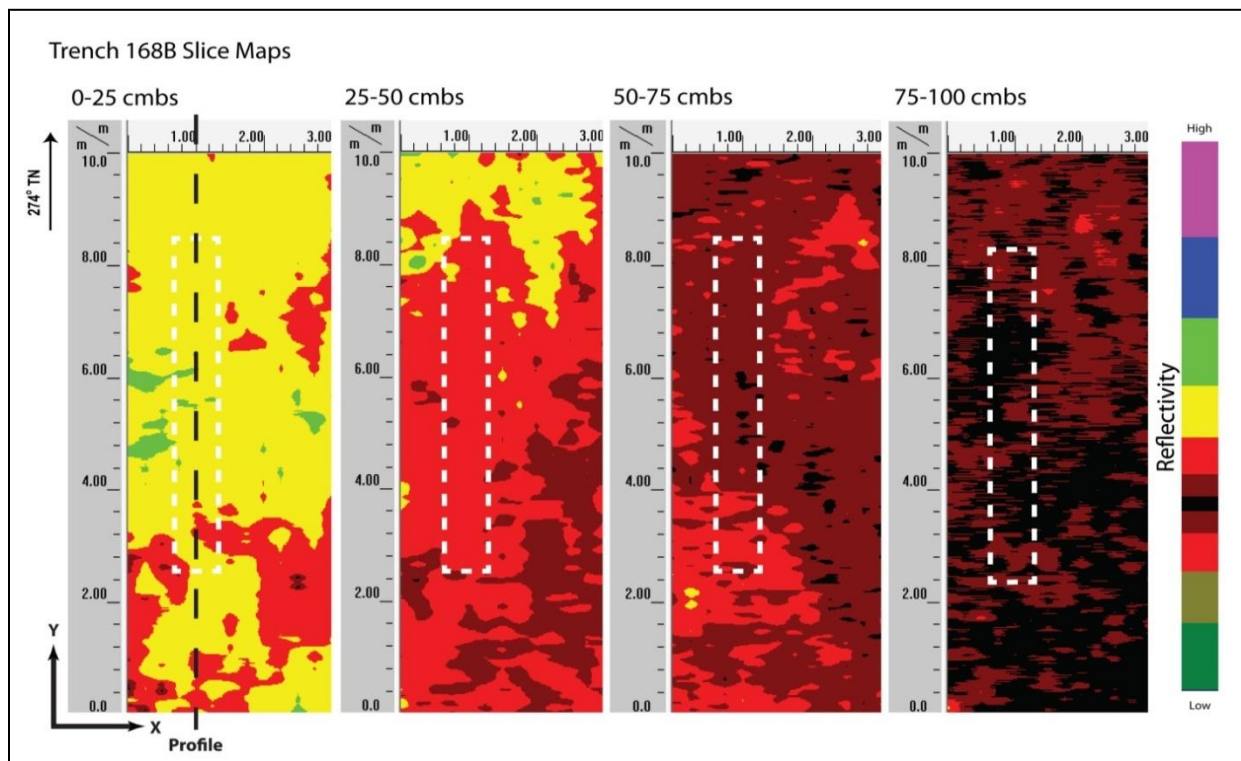


Figure 127. Slice maps of T-168B at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 128). Strata Ia to Ic were clearly observed and occurred at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum Ic which was sandy clay loam fill. A utility pipe was found 1.38 mbs. This pipe did not show up on the profile or slice maps because it was well below the maximum clean signal return depth. No other discrete objects were observed in the GPR results or subsequent excavation.

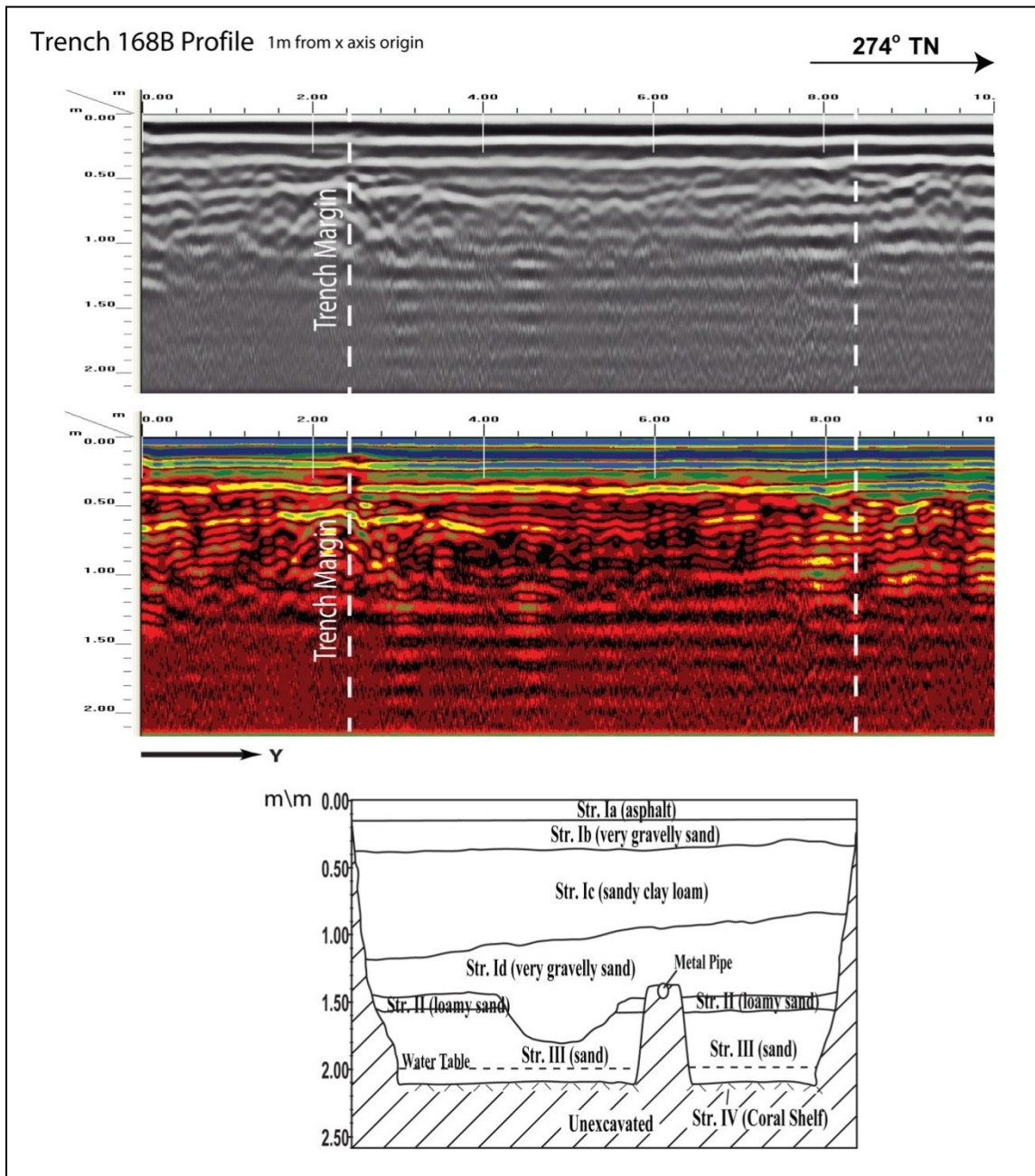


Figure 128. Visual comparison of excavated profile and GPR signal profile of T-168B

Test Excavation 169

T-169 measured 0.9 m by 3.0 m and was oriented northeast to southwest and was located within the Ross Dress For Less parking lot, 95.0 m southeast of Ward Avenue and Ilaniwai Street intersection. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer line 1.5 m northwest. Two metal utility pipes were encountered during excavation 0.98 mbs and 1.36 mbs running diagonally through the center of the excavation location and the other on the southwest end, respectively.

A review of amplitude slice maps indicated no linear features although two utilities were encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 129).

GPR depth profiles for T-169 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 130). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.4 mbs. No utilities were observed in the profile although two metal utility pipes were encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

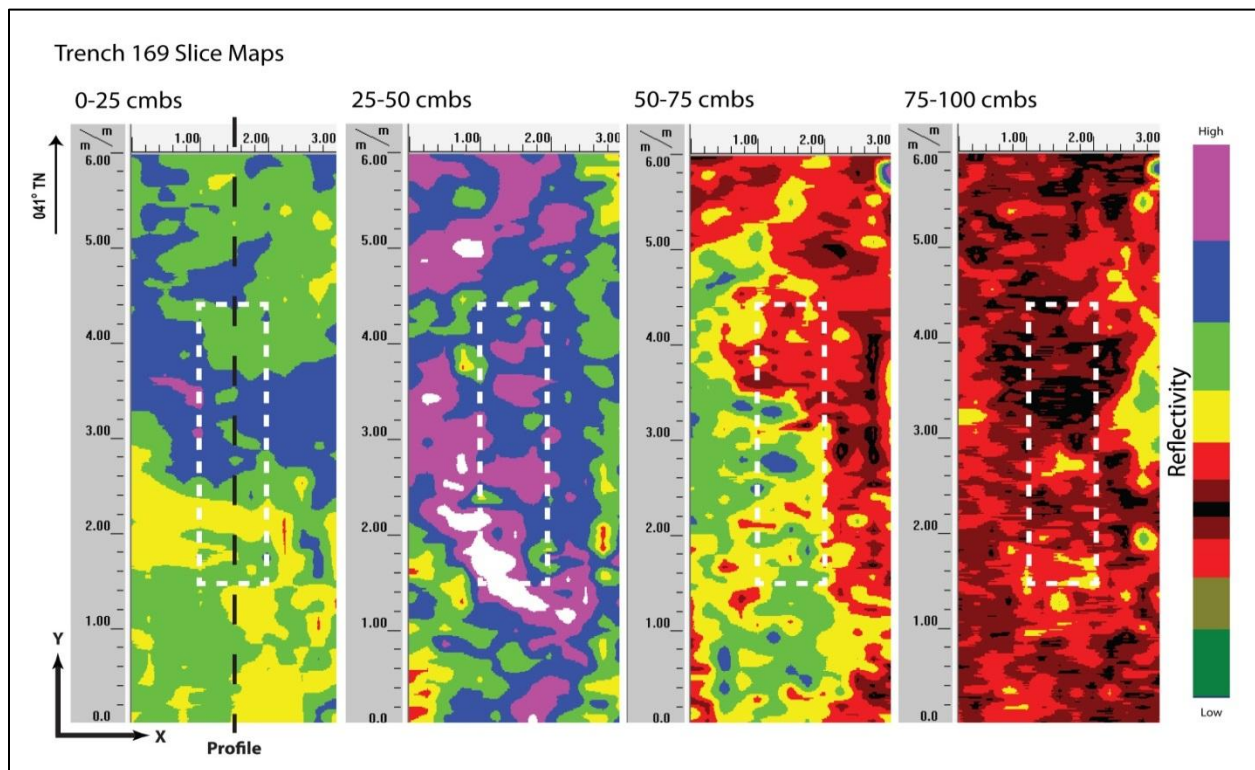


Figure 129. Slice maps of T-169 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 130). Strata included: asphalt, very gravelly silty sand, gravelly clay loam fill, gravelly clay loam fill, gravelly loamy sand fill, gravelly sand fill, clay fill, and natural sand. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. Two metal utility pipes were encountered during excavation 0.98 mbs and 1.36 mbs. These pipes did not show up on the profile or slice maps. This was due to the fact that the pipes were below or right at the maximum clean signal return depth. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

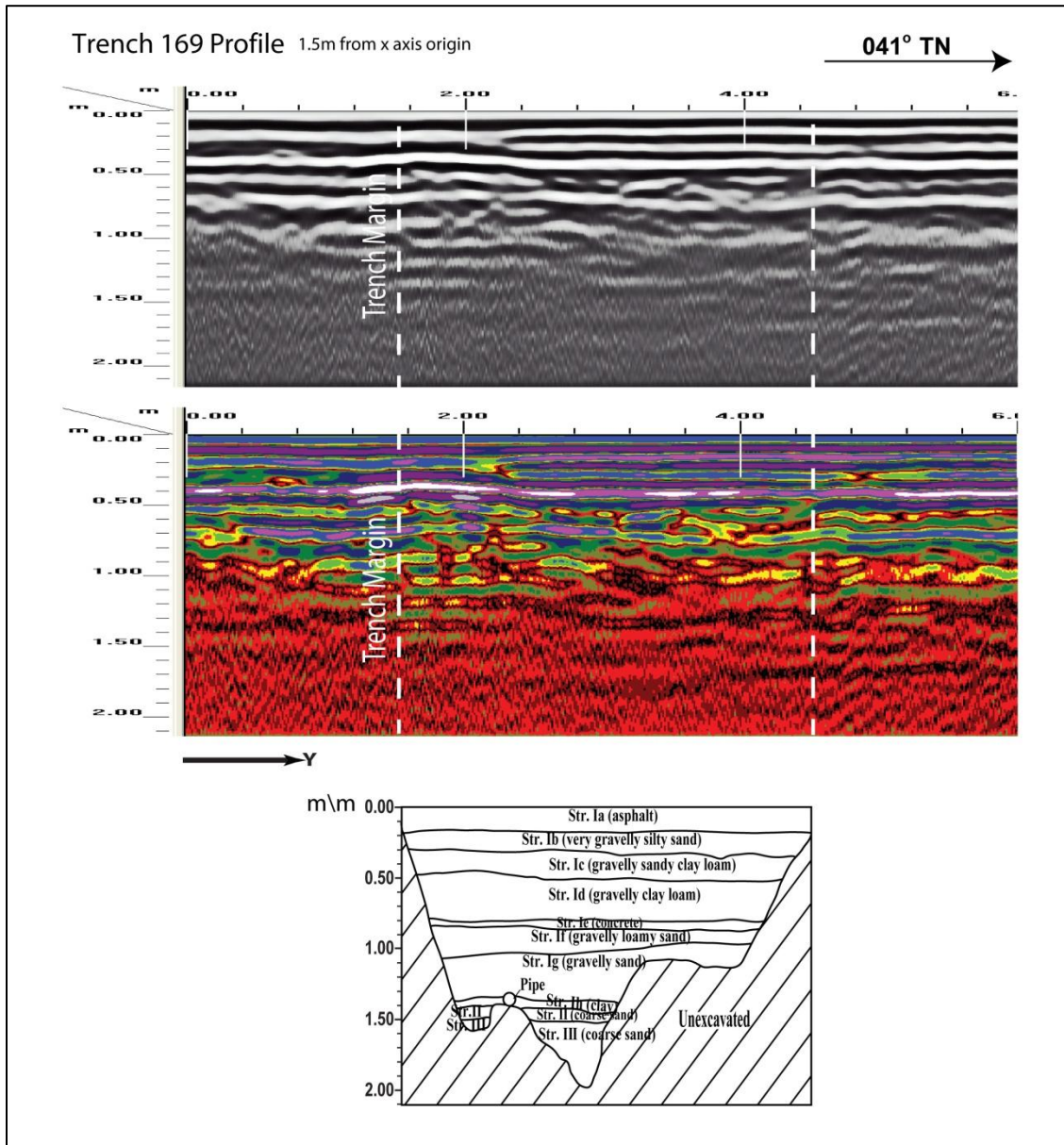


Figure 130. Visual comparison of excavated profile and GPR signal profile of T-169

Test Excavation 170

T-170 measured 0.9 m by 3.0 m and was oriented northeast to southwest and was located within an alley behind Ross Dress For Less parking lot, 96.0 m west of Queen Street and Cummins Street intersection. The GPR grid measured 3.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities located within close proximity to the excavation. No utilities transected the GPR grid or excavation location but an isolated human skeletal fragment was encountered between 0.65-0.71 mbs in the southeast wall of the excavation.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 131).

GPR depth profiles for T-170 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 132). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.3 mbs.

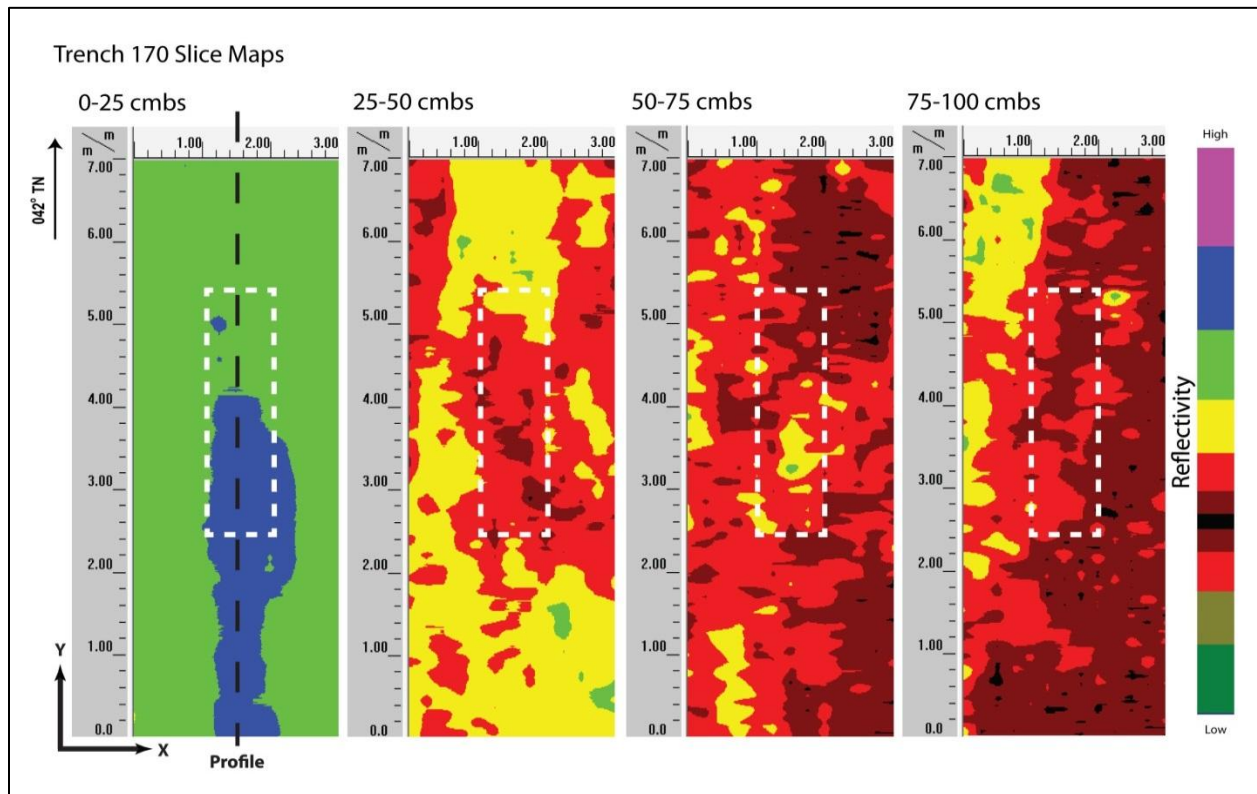


Figure 131. Slice maps of T-170 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 132). Strata Ia to Ic were all clearly observed and occurred near the ground-truthed depths. An increase in reflectivity was observed around 0.4 mbs and may represent sand located at this depth. No discrete objects were observed in the GPR results or subsequent excavation.

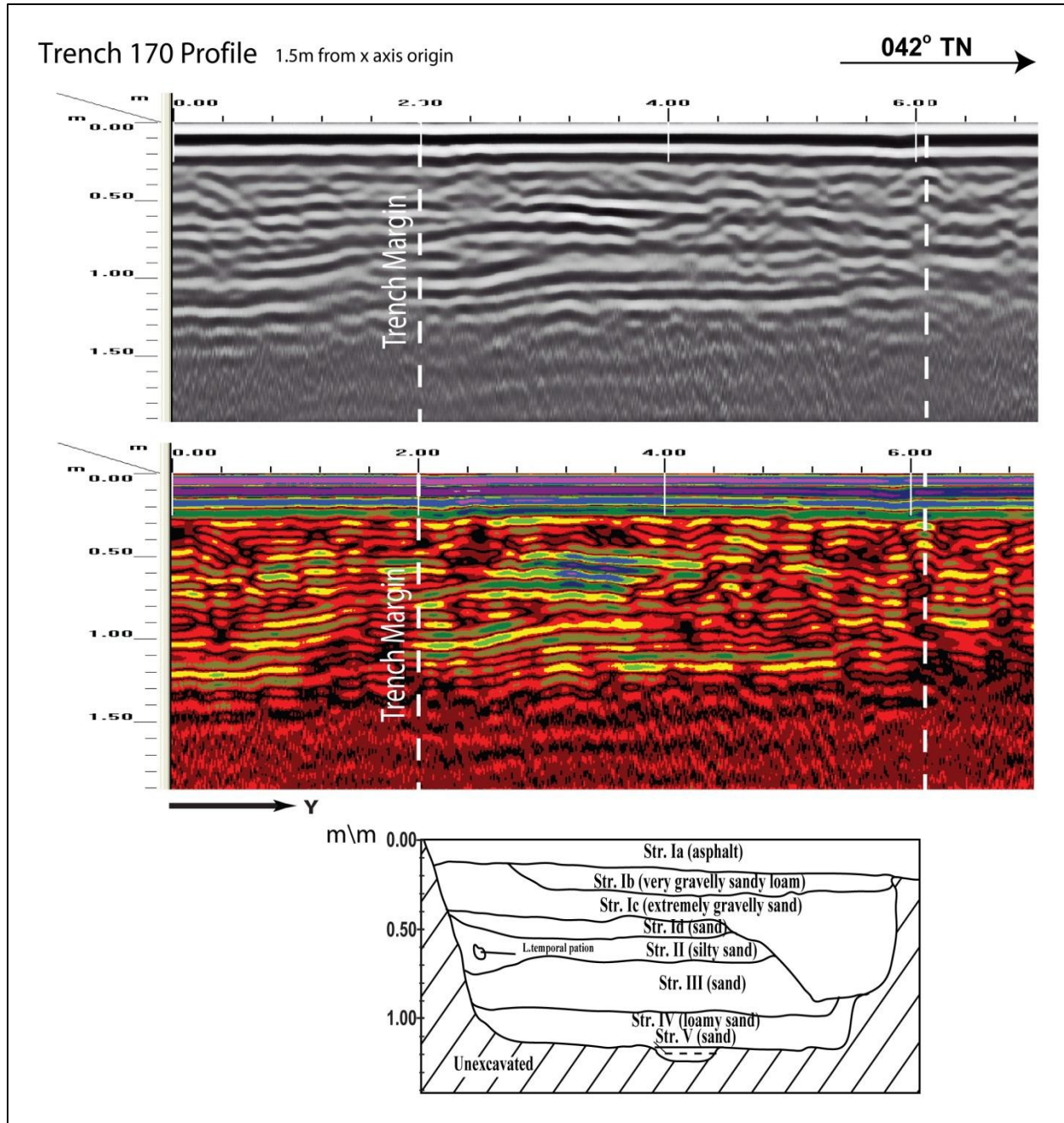


Figure 132. Visual comparison of excavated profile and GPR signal profile of T-170

Test Excavation 170A

T-170A measured 0.9 m by 3.0 m and was oriented northeast to southwest and was located within a parking lot 62.0 m southwest of Queen Street, 98.0 m northwest of Queen Street and Cummings Street intersection. The GPR grid measured 3.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 9.3 m northwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 133).

GPR depth profiles for T-170A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 134). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs and again around 0.5 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.2 mbs.

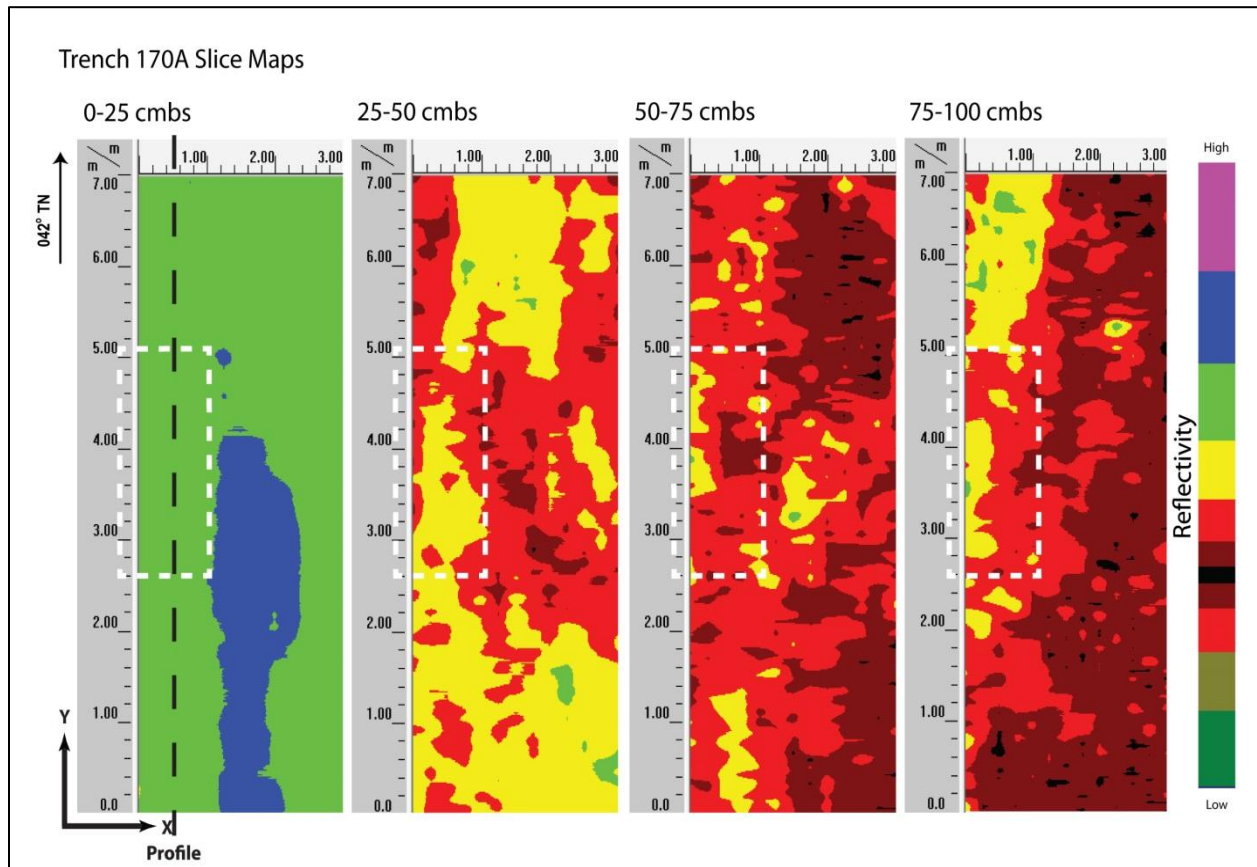


Figure 133. Slice maps of T-170A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 134). Strata Ia to Ic were all clearly observed and occurred at the ground-truthed depths. Strata included: asphalt, very gravelly loam fill, extremely gravelly sand fill, fine sand fill, natural silty coarse sand, and natural coarse sand. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

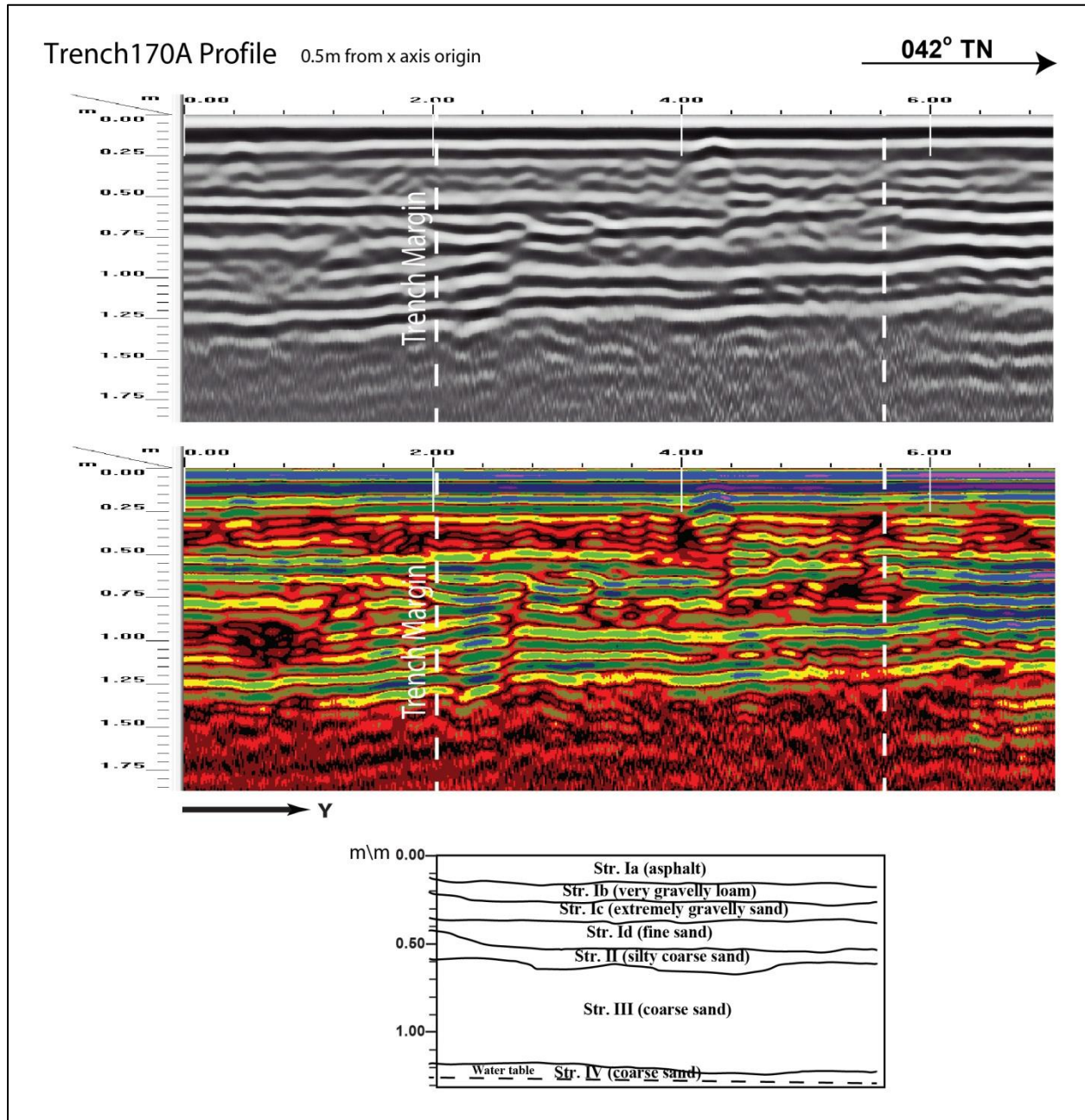


Figure 134. Visual comparison of excavated profile and GPR signal profile of T-170

Test Excavation 171

T-171 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the parking lot of DKKY Architecture, 55.0 m west of Queen Street and Cummins Street intersection. The GPR grid measured 3.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity to the excavation location. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 135).

GPR depth profiles for T-171 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 136). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

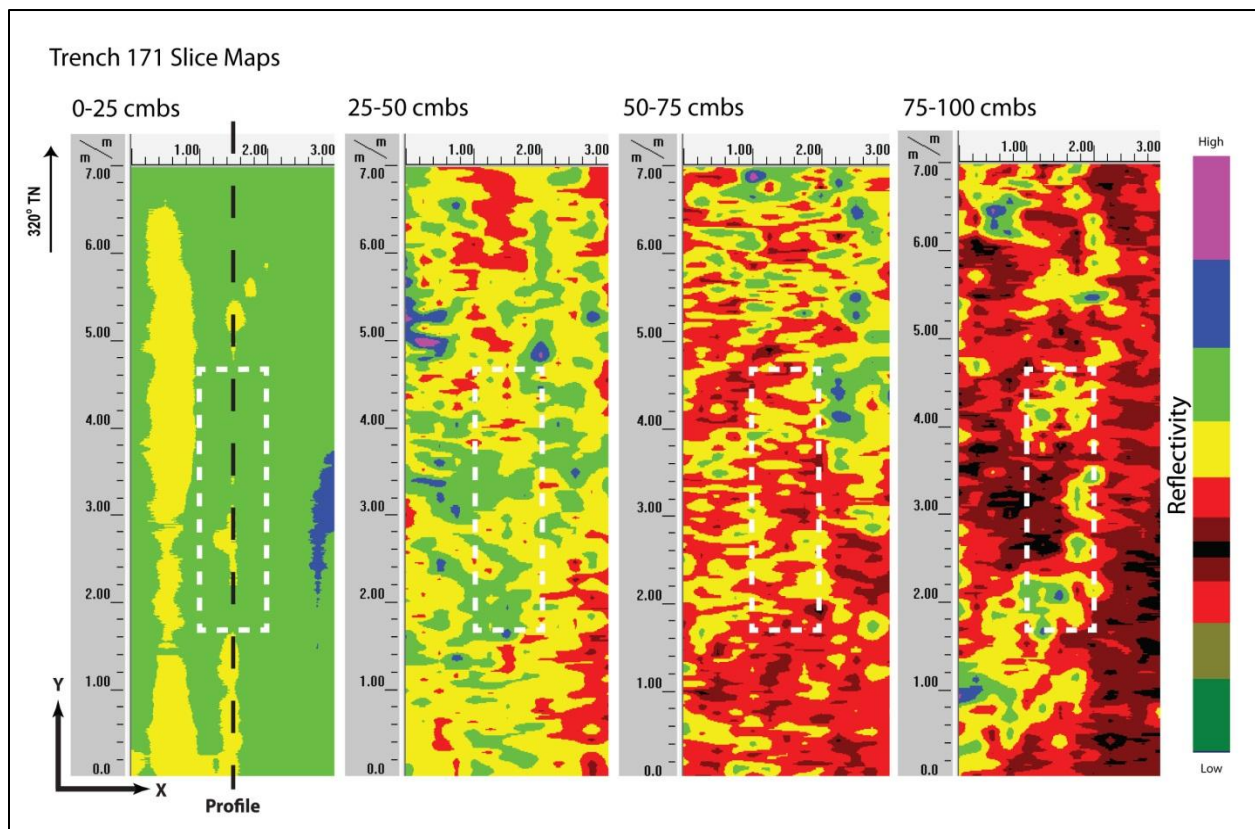


Figure 135. Slice maps of T-171 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 136). Strata Ia to If were clearly observed and occurred at the ground-truthed depths. Strata Ia to Id may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

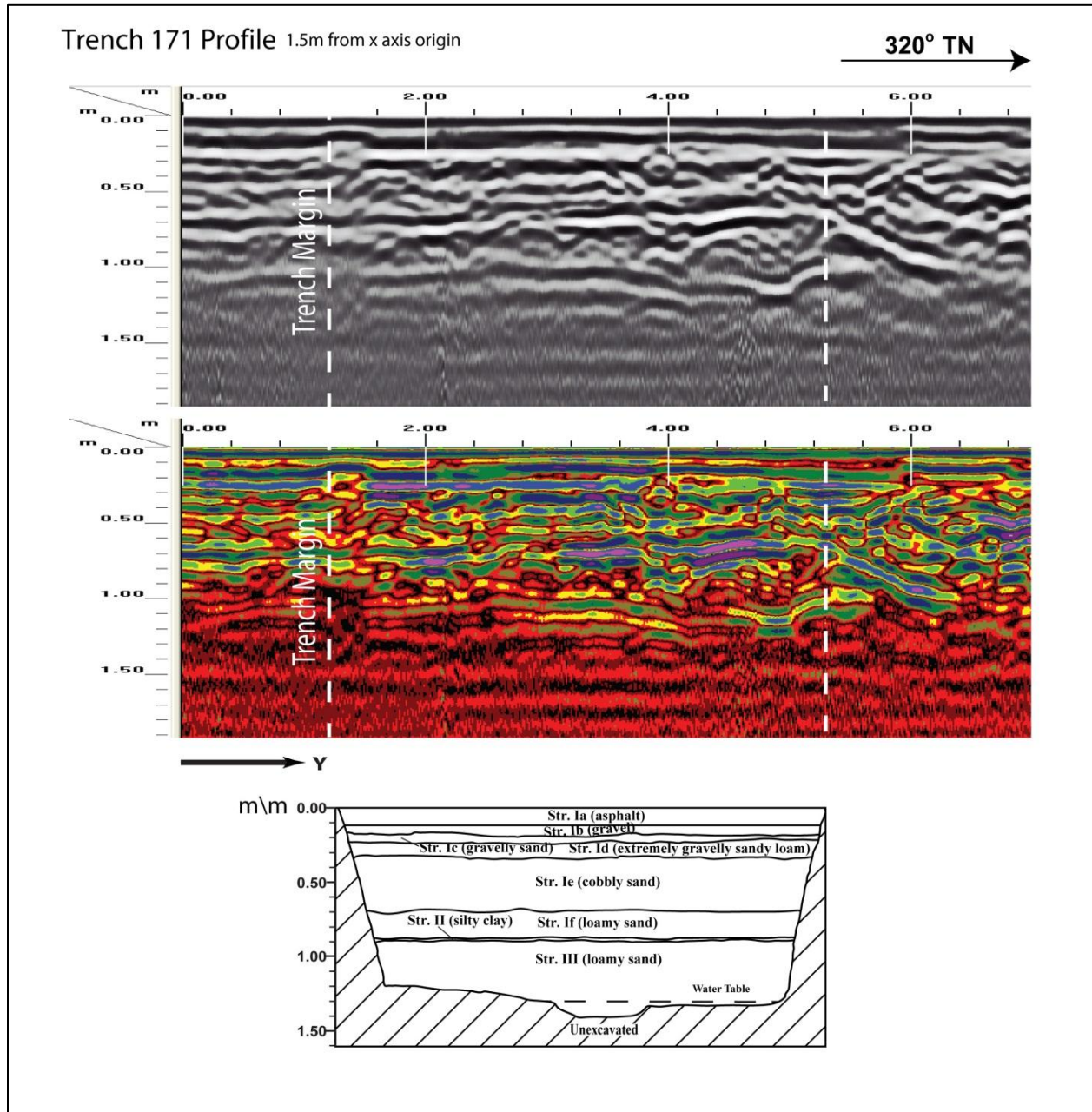


Figure 136. Visual comparison of excavated profile and GPR signal profile of T-171

Test Excavation 172

T-172 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the parking lot of DKKY Architecture, 31.0 m southwest of Queen Street and Cummins Street intersection. The GPR grid measured 3.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity of the excavation.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 137).

GPR depth profiles for T-172 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 138). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

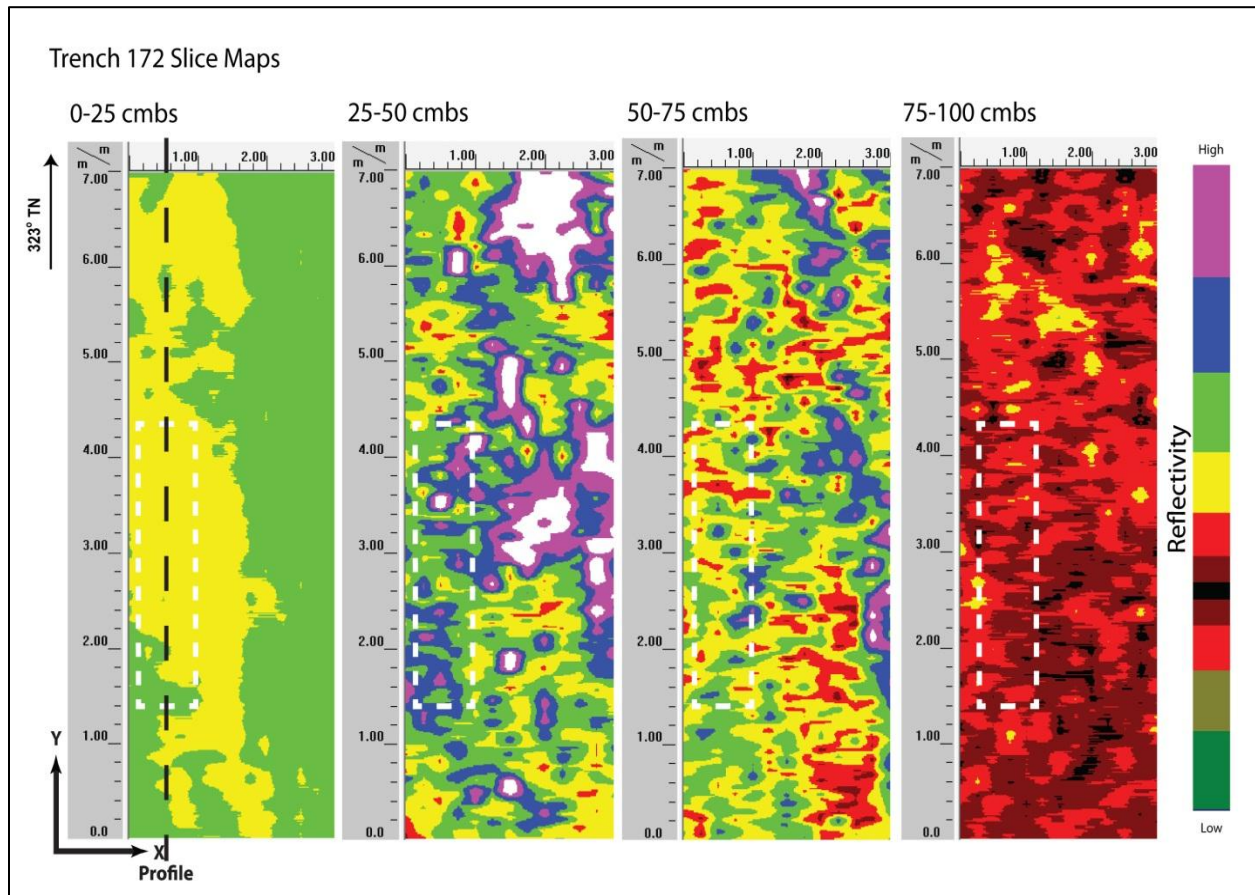


Figure 137. Slice maps of T-172 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 138). Strata Ia to Ig were clearly observed and occurred at the ground-truthed depths. Strata Ia to If may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

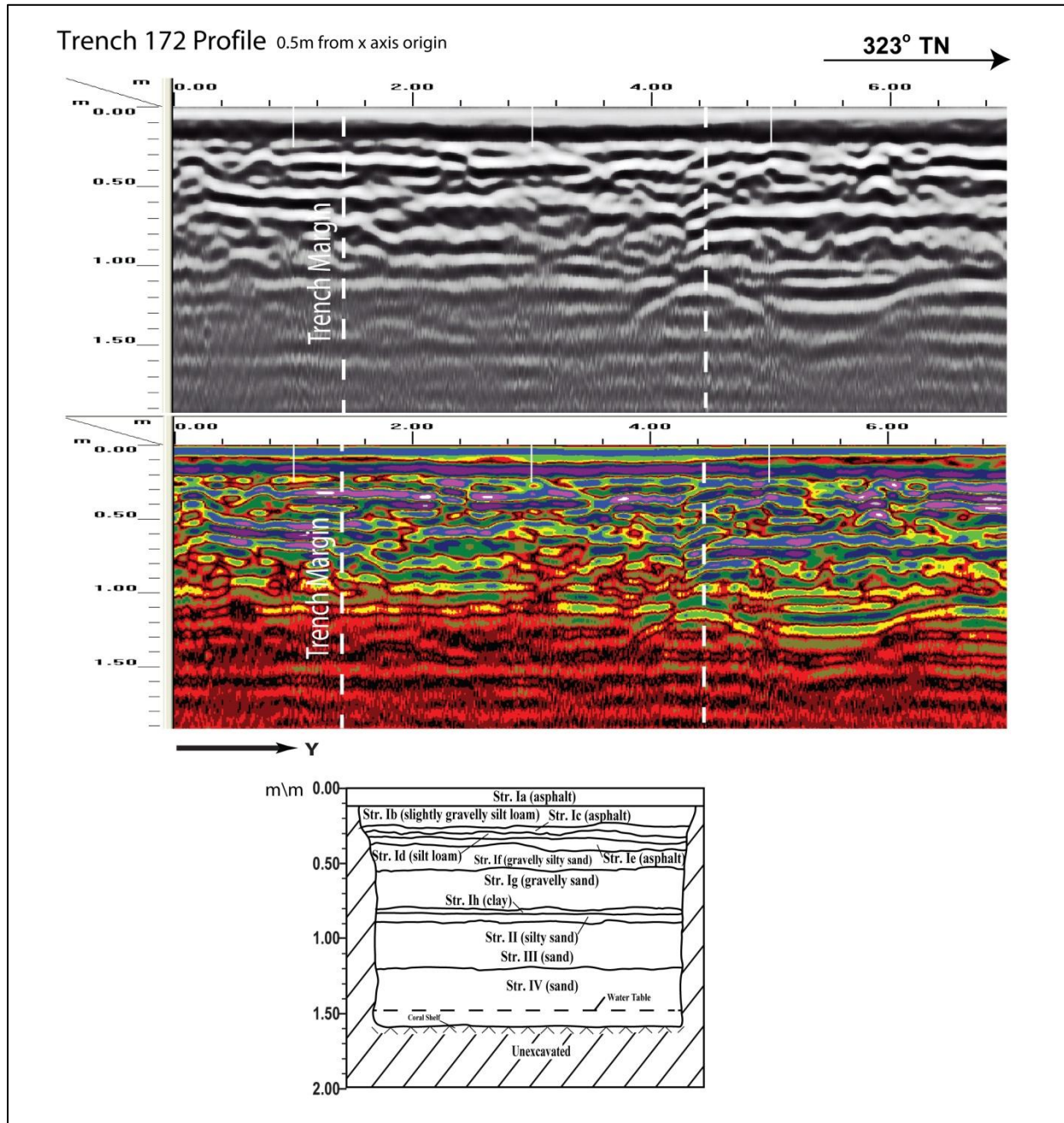


Figure 138. Visual comparison of excavated profile and GPR signal profile of T-172

Test Excavation 172A

T-172A measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the parking lot of DKKY Architecture, 29.0 m southwest of Queen Street and Cummins Street intersection. The GPR grid measured 3.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity of the excavation. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 139).

GPR depth profiles for T-172A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 140). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.1 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

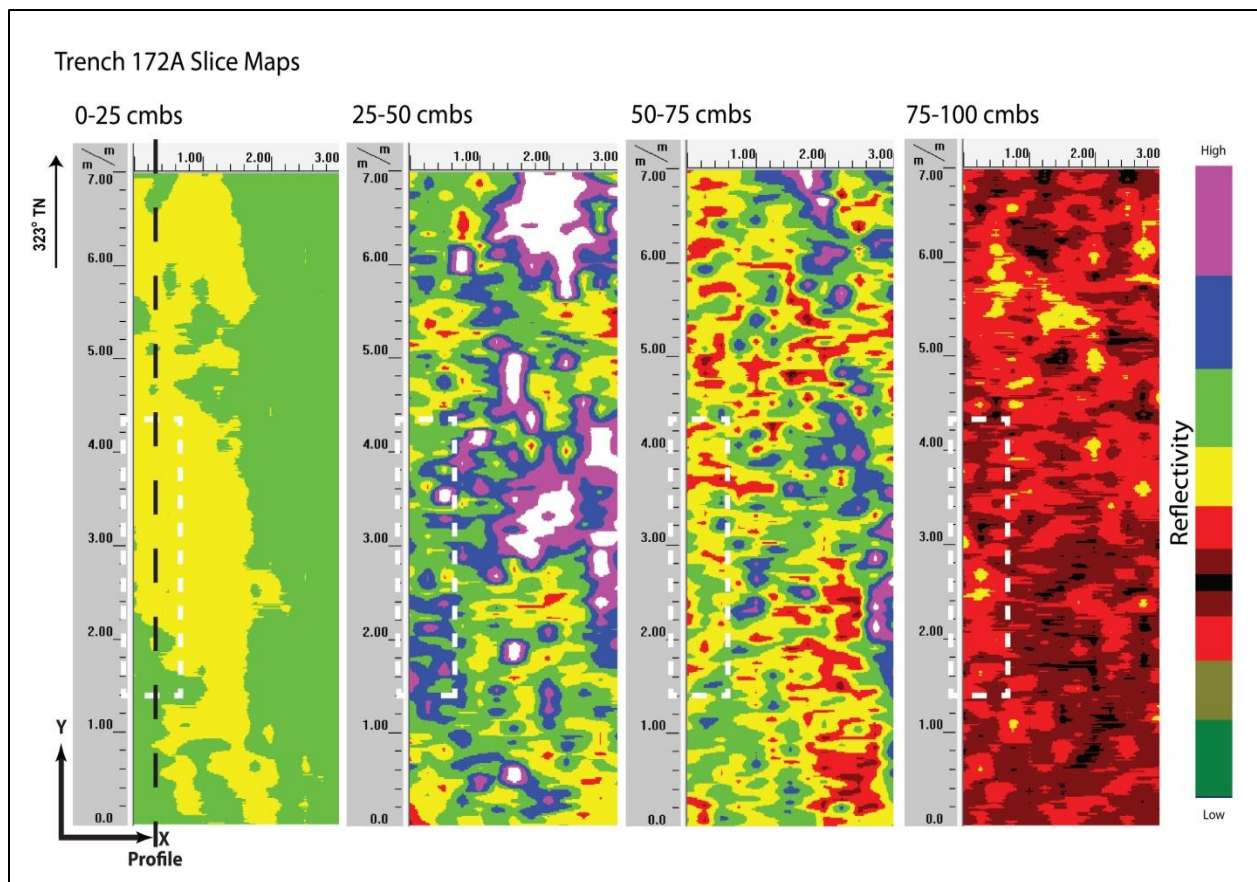


Figure 139. Slice maps of T-172A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 140). Strata Ia to If were observed and occurred at the ground-truthed depths. Strata Ia through If were difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

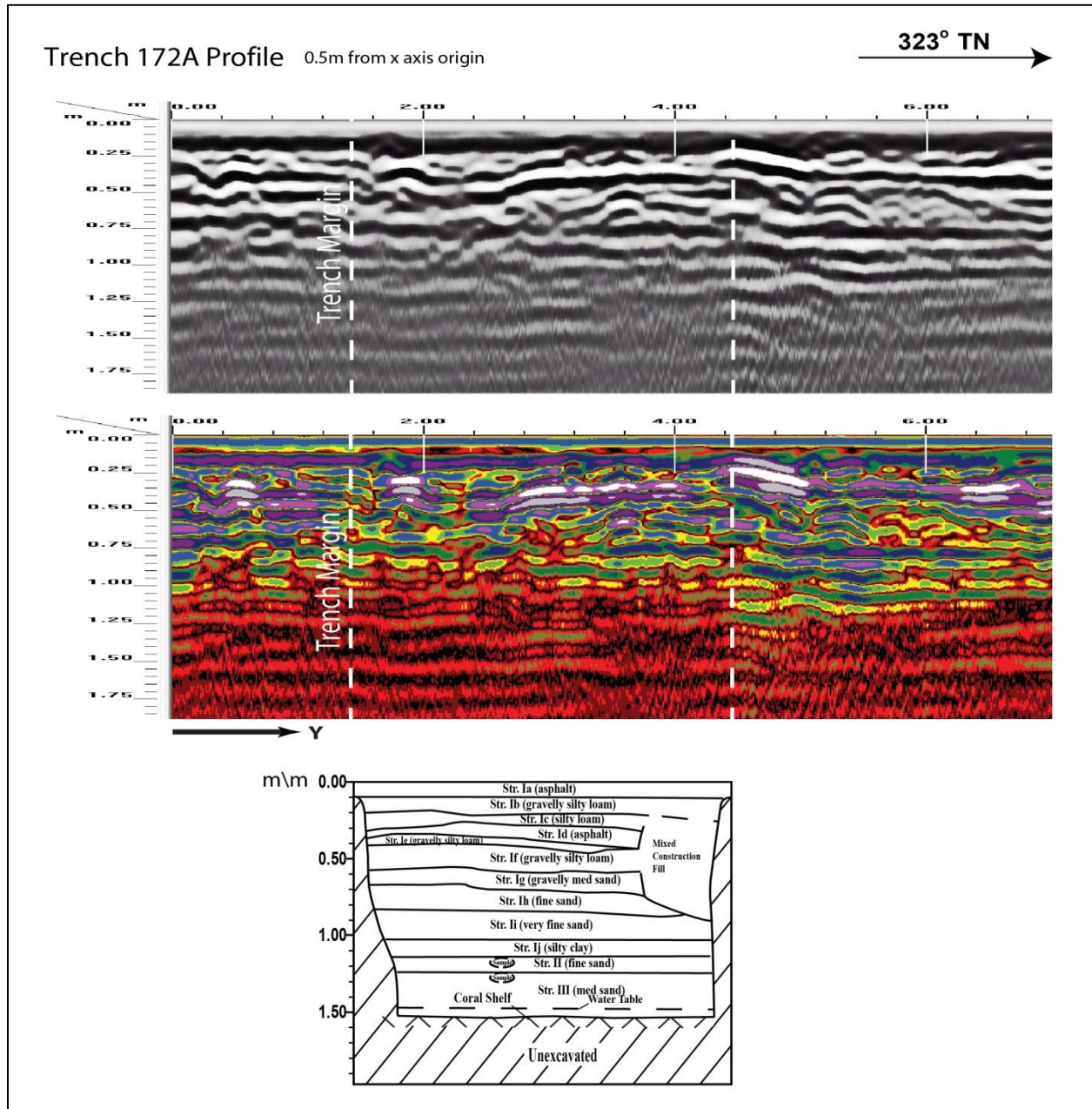


Figure 140. Visual comparison of excavated profile and GPR signal profile of T-172A

Test Excavation 173

T-173 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the parking lot of DKKY Architecture, 51.0 m south of Queen Street and Cummins Street intersection. The GPR grid measured 3.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 2.3 m southeast, water line 2.4 m south. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 141).

GPR depth profiles for T-173 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 142). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs and again at 0.5 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

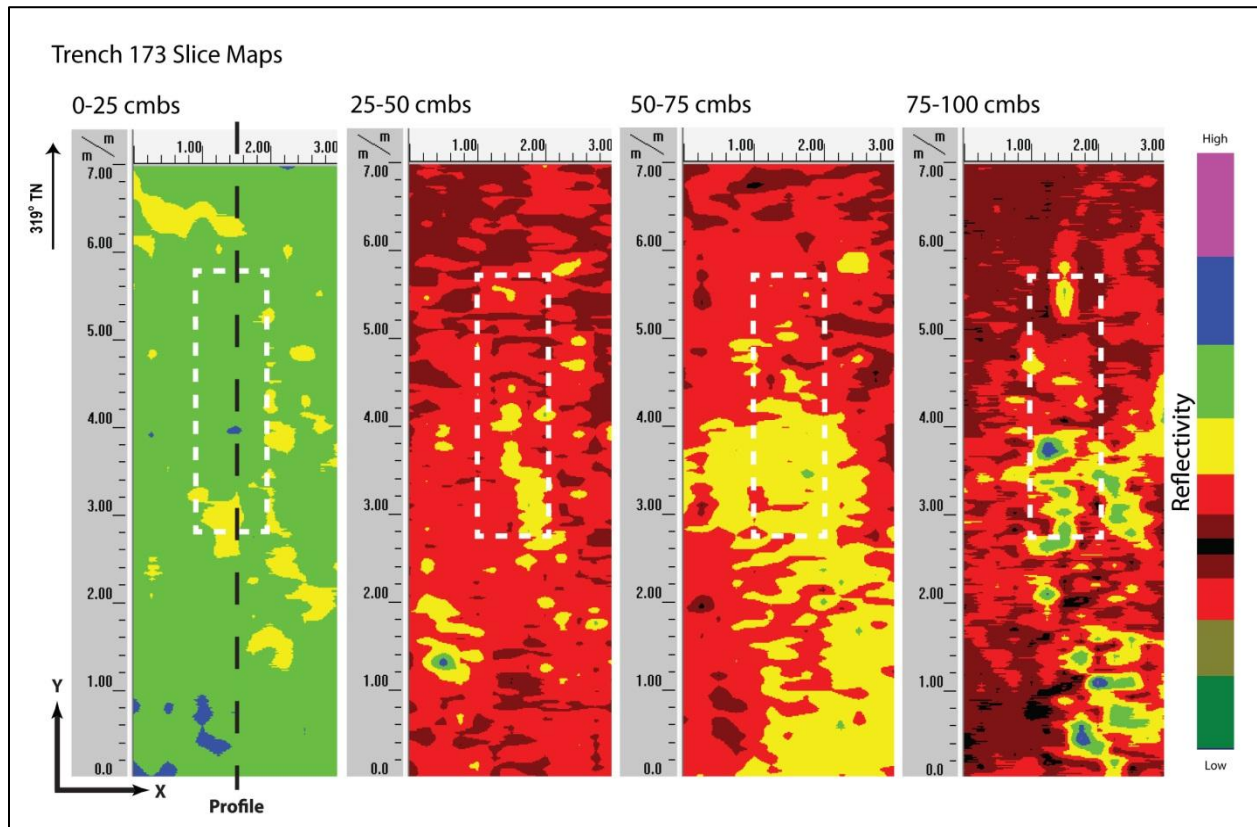


Figure 141. Slice maps of T-173 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 142). Strata Ia to Ig were clearly observed and occurred at the ground-truthed depths. Strata Ia to Ie may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

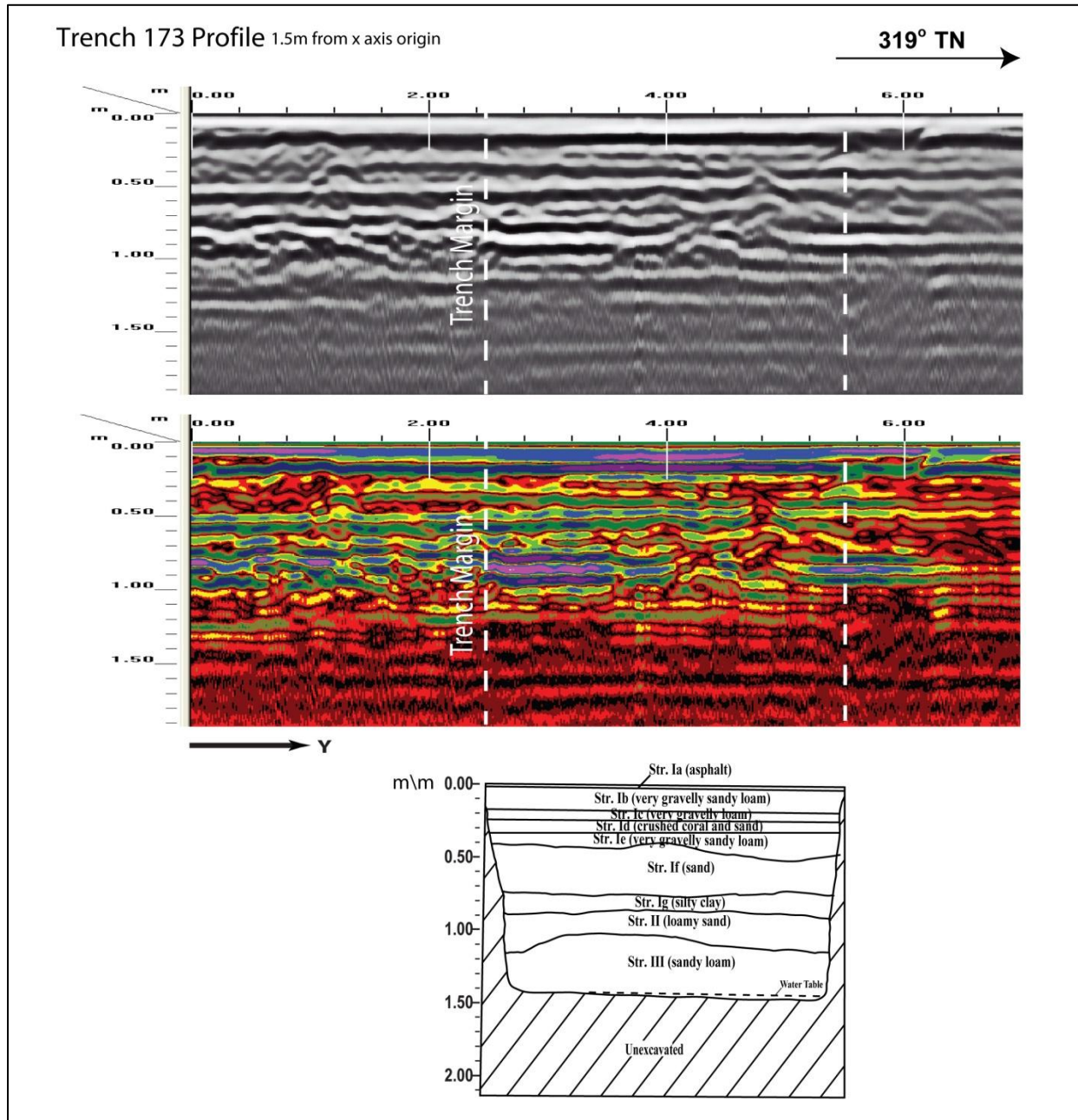


Figure 142. Visual comparison of excavated profile and GPR signal profile of T-173

Test Excavation 174

T-174 measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the parking lot of DKKY Architecture, 56.0 m southeast of Queen Street and Cummins Street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 1.5 m southeast and gas line 2.0 m northwest, 1.0 m northeast and 2.3 m southeast. Utility lines were encountered 0.44 and 0.6 mbs on the northeastern end of T-174.

A review of amplitude slice maps indicated linear features which could corresponded to one of the utilities encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 143).

GPR depth profiles for T-174 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 144). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs. Several anomalies were observed in the profile and one seems to corresponded to a utility that was encountered during excavation. The maximum depth of clean signal return was approximately 1.4 mbs.

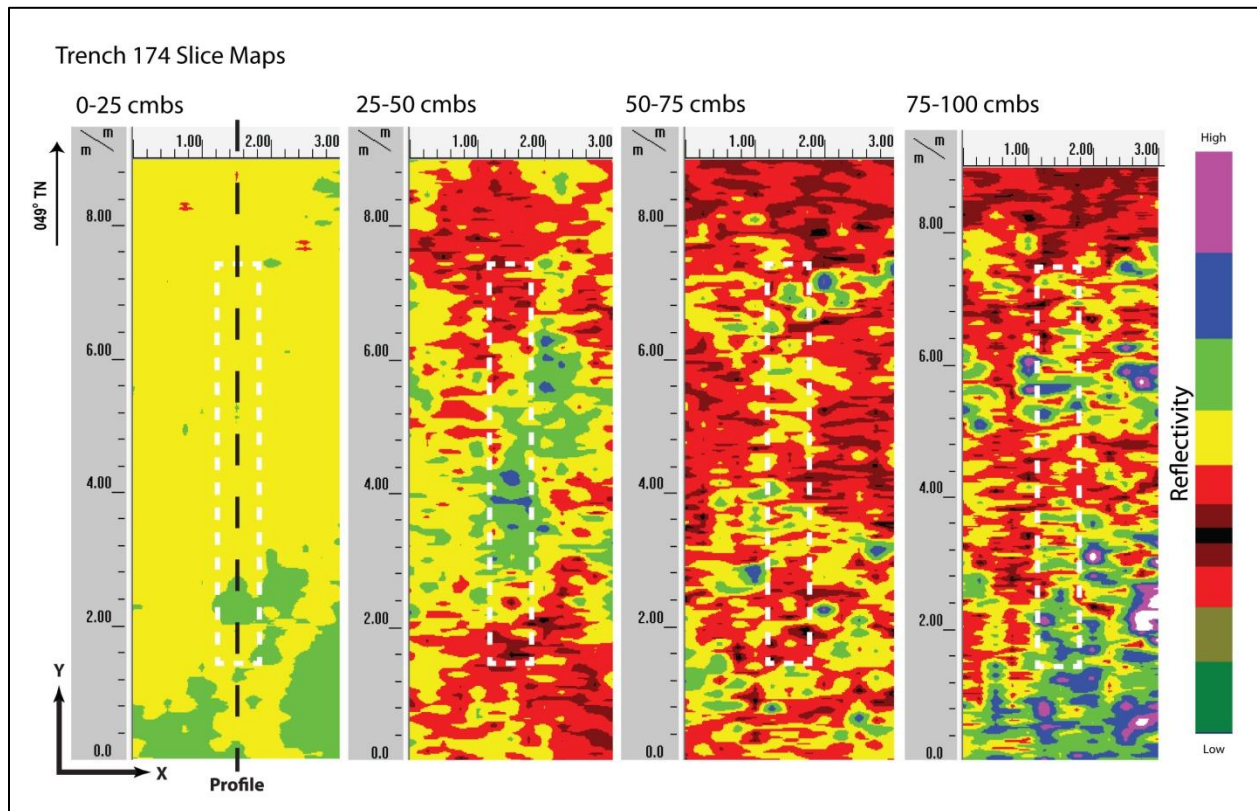


Figure 143. Slice maps of T-174 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 144). Strata included: asphalt, gravelly sandy loam fill, gravelly sandy loam fill, sandy fill, sandy loam fill, natural sand, and natural sandy loam. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. Two utility pipes were found 0.44 and 0.6 mbs. A small hyperbola anomaly was observed around 0.4 mbs and this corresponded to the utility pipe found at this same location. No other discrete objects or stratigraphic transitions were observed in the GPR results or subsequent excavation.

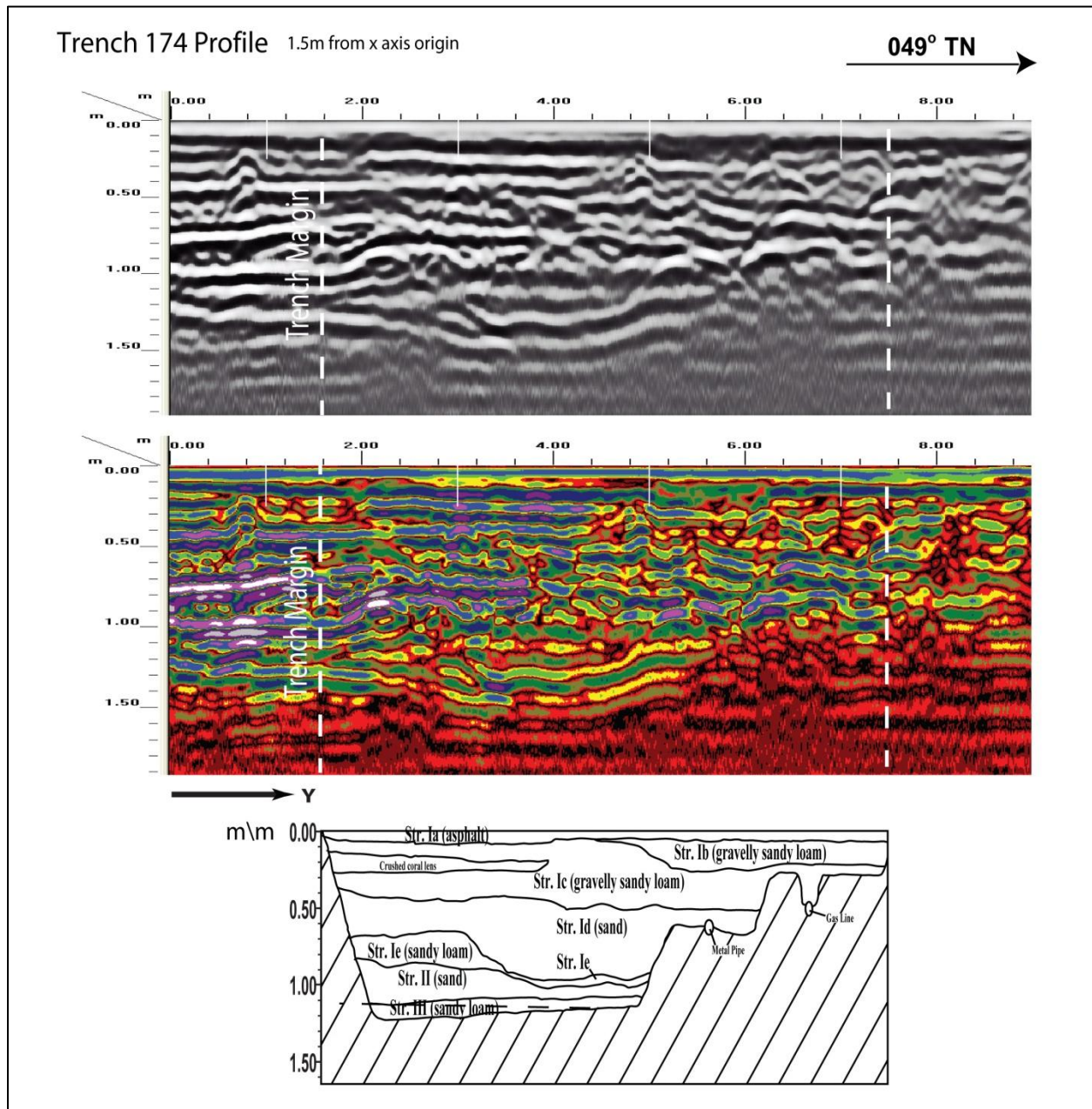


Figure 144. Visual comparison of excavated profile and GPR signal profile of T-174

Test Excavation 174A

T-174A measured 0.9 m by 3.0 m and was oriented north to south and was located within the parking lot of DKKY Architecture, 51.0 m southeast of Queen Street and Cummins Street intersection. The GPR grid measured 2.5 m by 8.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 2.5 m southeast, gas line 1 m south and 5.0 m northeast. Utility lines were encountered 0.36 and 0.5 mbs and spanned the length of the excavation.

A review of amplitude slice maps indicated no linear features although several utilities were encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 145).

GPR depth profiles for T-174A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 146). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. An anomaly was observed in the profile but not within excavation boundaries. The maximum depth of clean signal return was approximately 0.85 mbs.

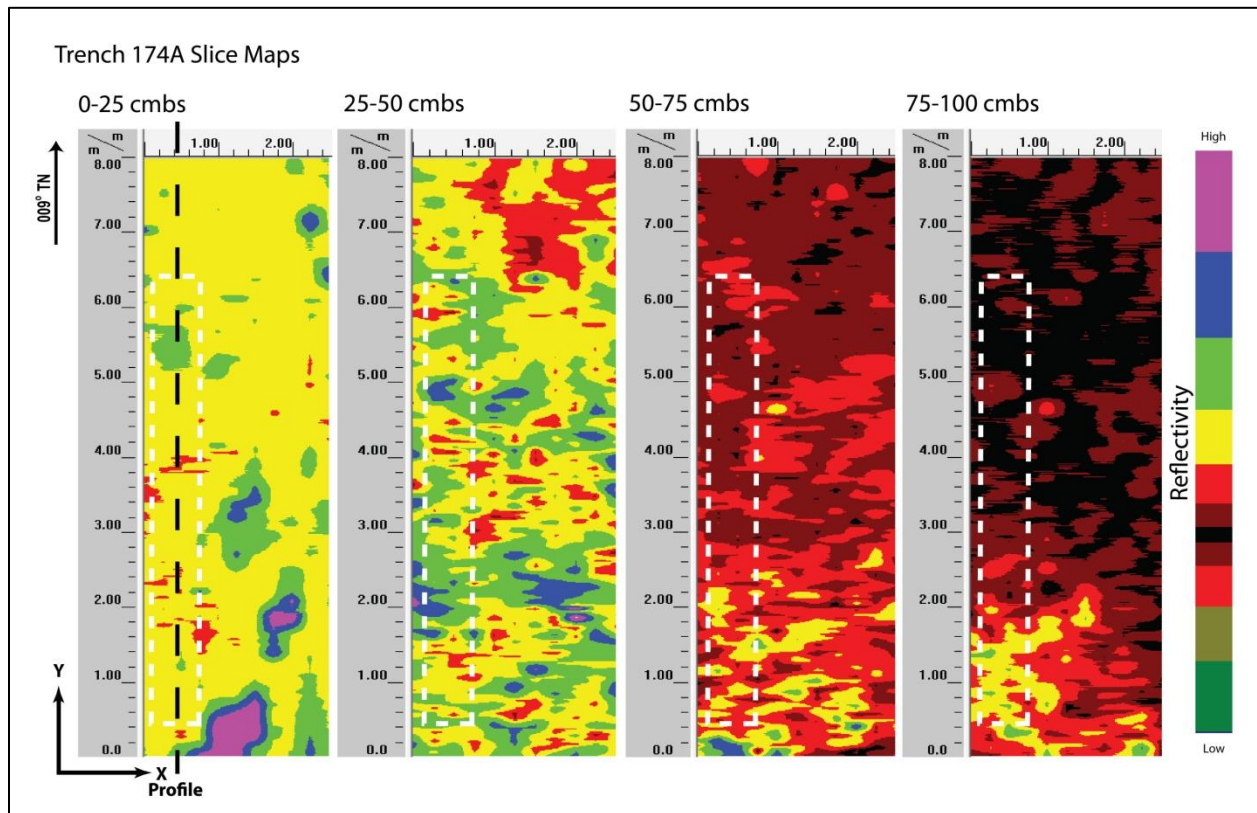


Figure 145. Slice maps of T-174A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 146). Strata Ia to Ie were clearly observed and occurred at the ground-truthed depths. Strata Ib and Ic were difficult to individually discern, possibly due to the fact that they were thin layers of similar compacted fill. Utility pipes were found 0.36 and 0.5 mbs. The pipes did not show up on the profile or slice maps. This may be due to the fact that the pipes may have been empty or the pipes could have had a similar density to the surrounding stratum. No other discrete objects were observed in the GPR results or subsequent excavation.

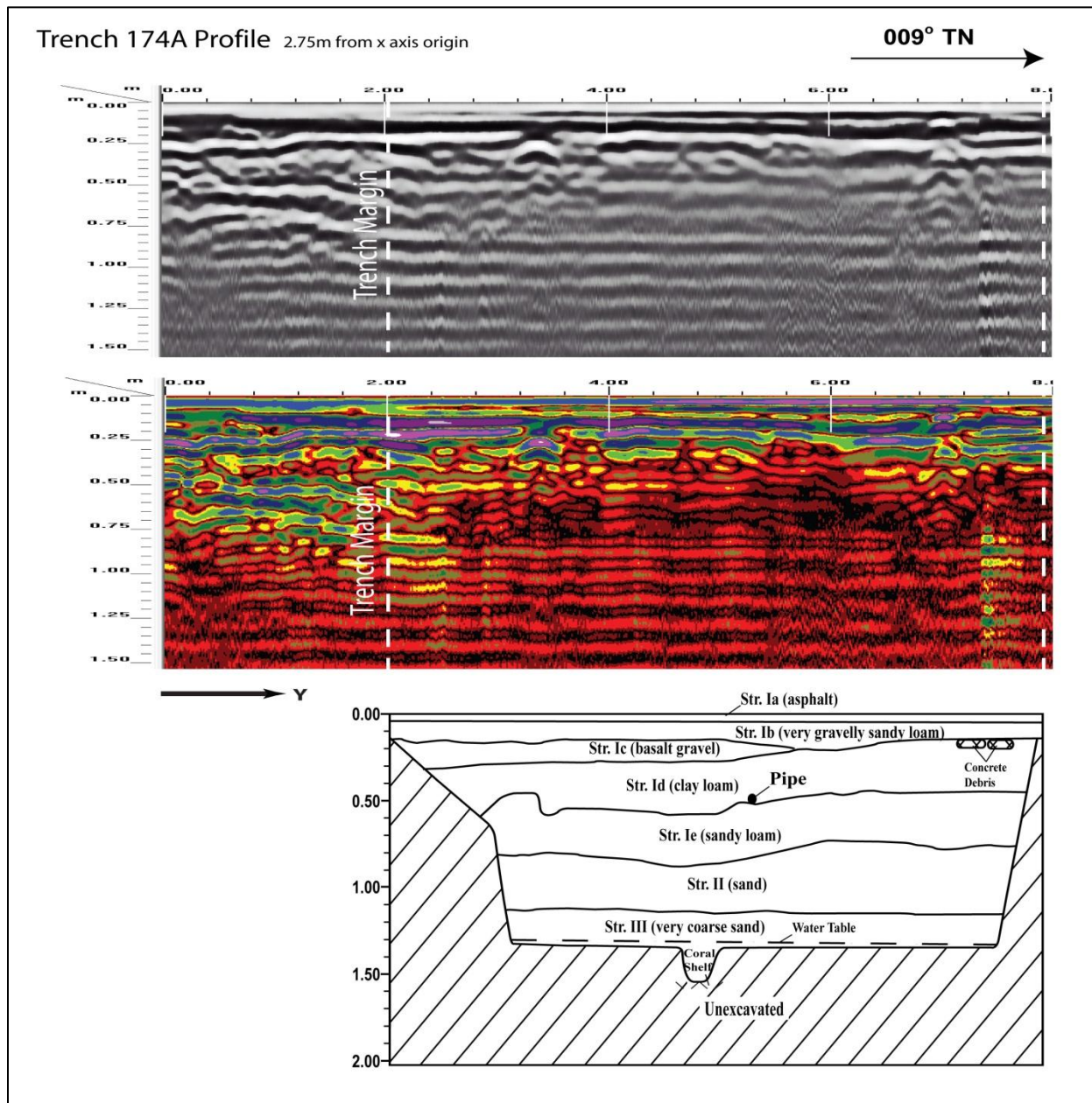


Figure 146. Visual comparison of excavated profile and GPR signal profile of T-174A

Test Excavation 175

T-175 measured 0.9 m by 3.0 m and was oriented northeast to southwest and was located within an alley along Office Depot, 90.0 m southeast of Queen Street and Cummins Street intersection. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line against the southwest wall, water line 5.6 m northeast. Three utilities were encountered at 0.2 mbs running perpendicular along entire length of excavation location and spaced approximately 1.0 m apart and a concrete jacket was encountered 0.27 mbs in the southwest end.

A review of amplitude slice maps indicate linear features that corresponded to the utilities encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the utilities. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 147).

GPR depth profiles for T-175 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 148). This banding corresponded to variations of density and chemical composition within fill deposits. The profile indicated a change in reflectivity that occurred around 0.15 mbs. Several anomalies were observed in the profile and seem to corresponded to the utilities encountered during excavation. The maximum depth of clean signal return was approximately 1.25 mbs.

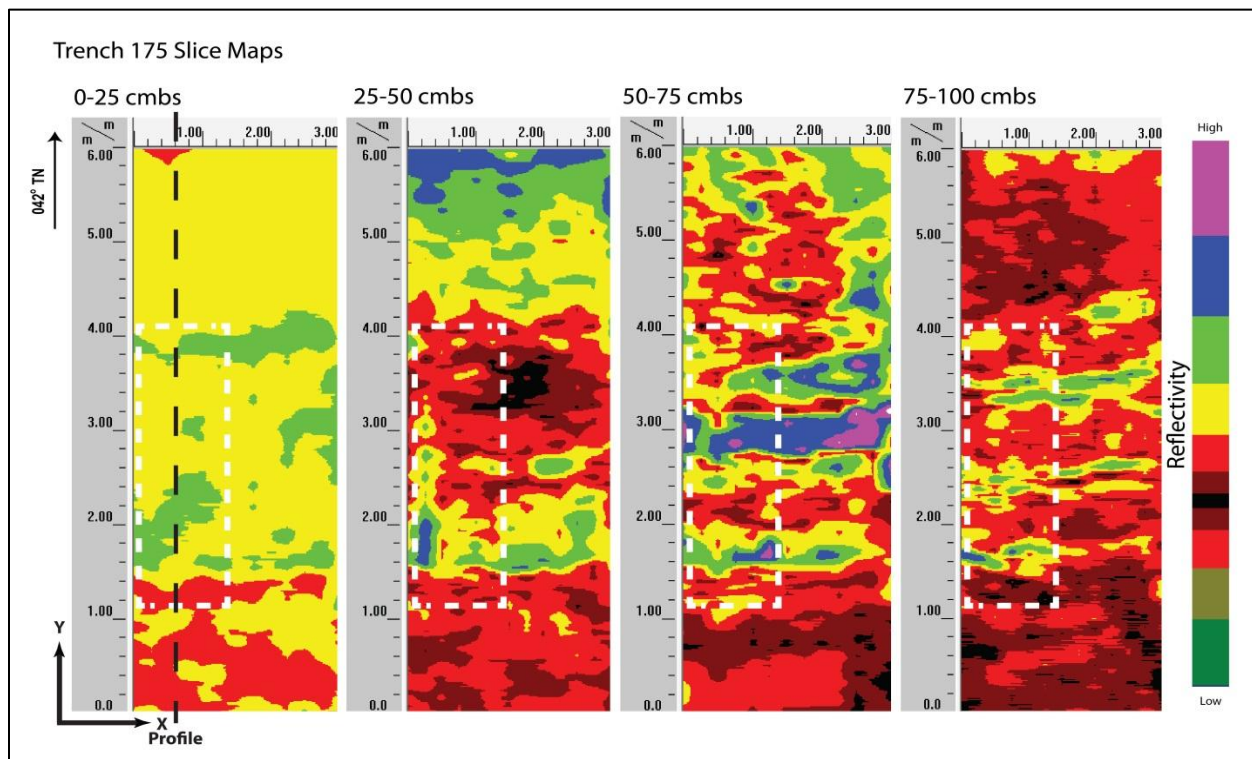


Figure 147. Slice maps of T-175 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 148). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. Several utilities were found 0.2 mbs. The utilities did showed up on both the profile and slice maps. No other discrete objects were observed in the GPR results or subsequent excavation.

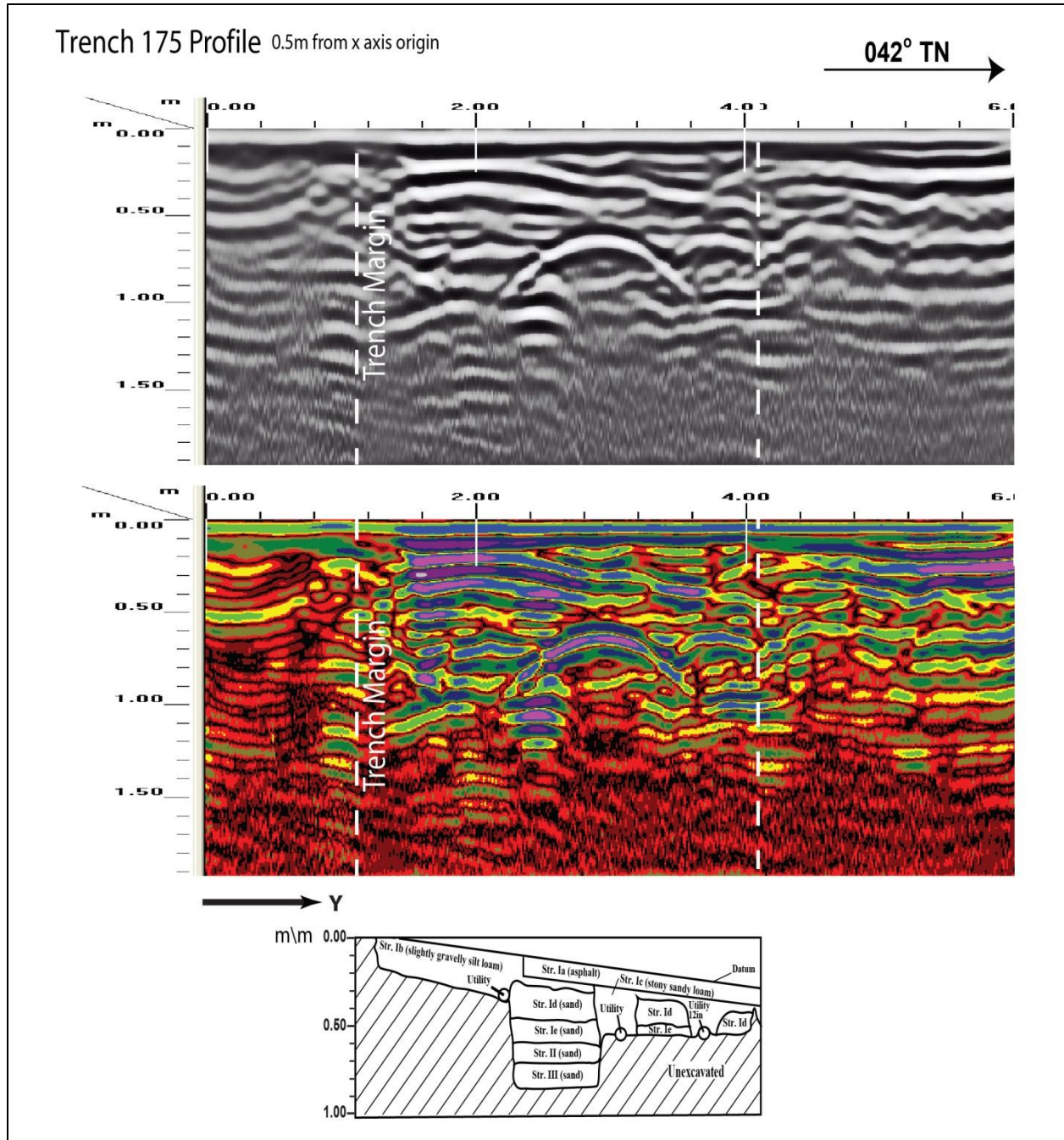


Figure 148. Visual comparison of excavated profile and GPR signal profile of T-175

Test Excavation 175A

T-175A measured 0.9 m by 3.0 m and was oriented northeast to southwest and was located within an alley between Office Depot and Queen Street, 138.0 m northwest of Queen Street and Kamakee Street intersection. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line against the southwest wall, water line 5.6 m northeast. Two large utility lines were encountered 0.5 mbs and extended through the center of the excavation.

A review of amplitude slice maps indicate linear features that corresponded to the utilities encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the utilities. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 149).

GPR depth profiles for T-175A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 150). This banding corresponded to variations of density and chemical composition within fill deposits. The profile indicated a change in reflectivity that occurred around 0.15 mbs. Several anomalies were observed in the profile and seem to corresponded to the utilities encountered during excavation. The maximum depth of clean signal return was approximately 1.25 mbs.

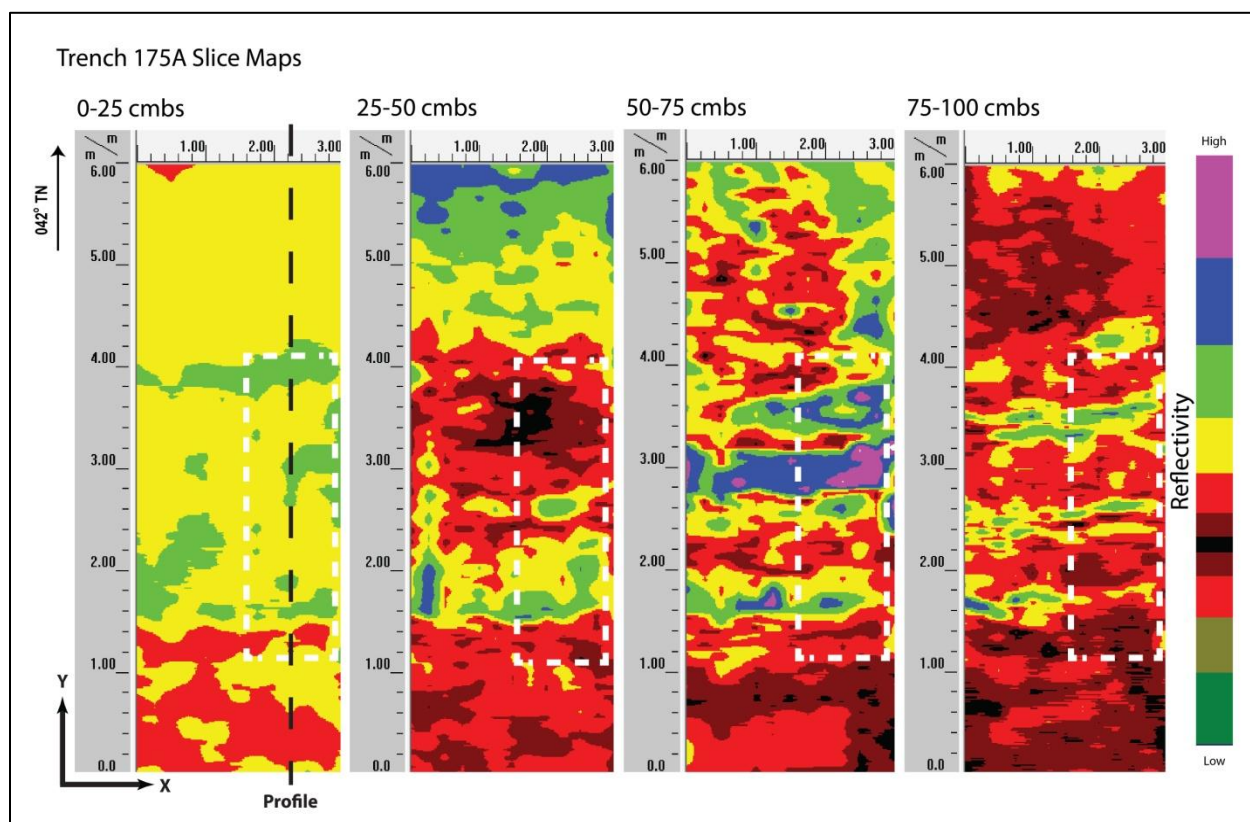


Figure 149. Slice maps of T-175A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 150). Strata Ia, Ib and Id were clearly observed and occurred at the ground-truthed depths. Strata included: asphalt, very gravelly sandy loam fill, coral sand fill, sand fill, natural loamy sand, natural sand, and natural sand. Two pipes were found 0.5 mbs. A hyperbola anomaly was observed in the profile and corresponded to the pipes that were encountered during excavation. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

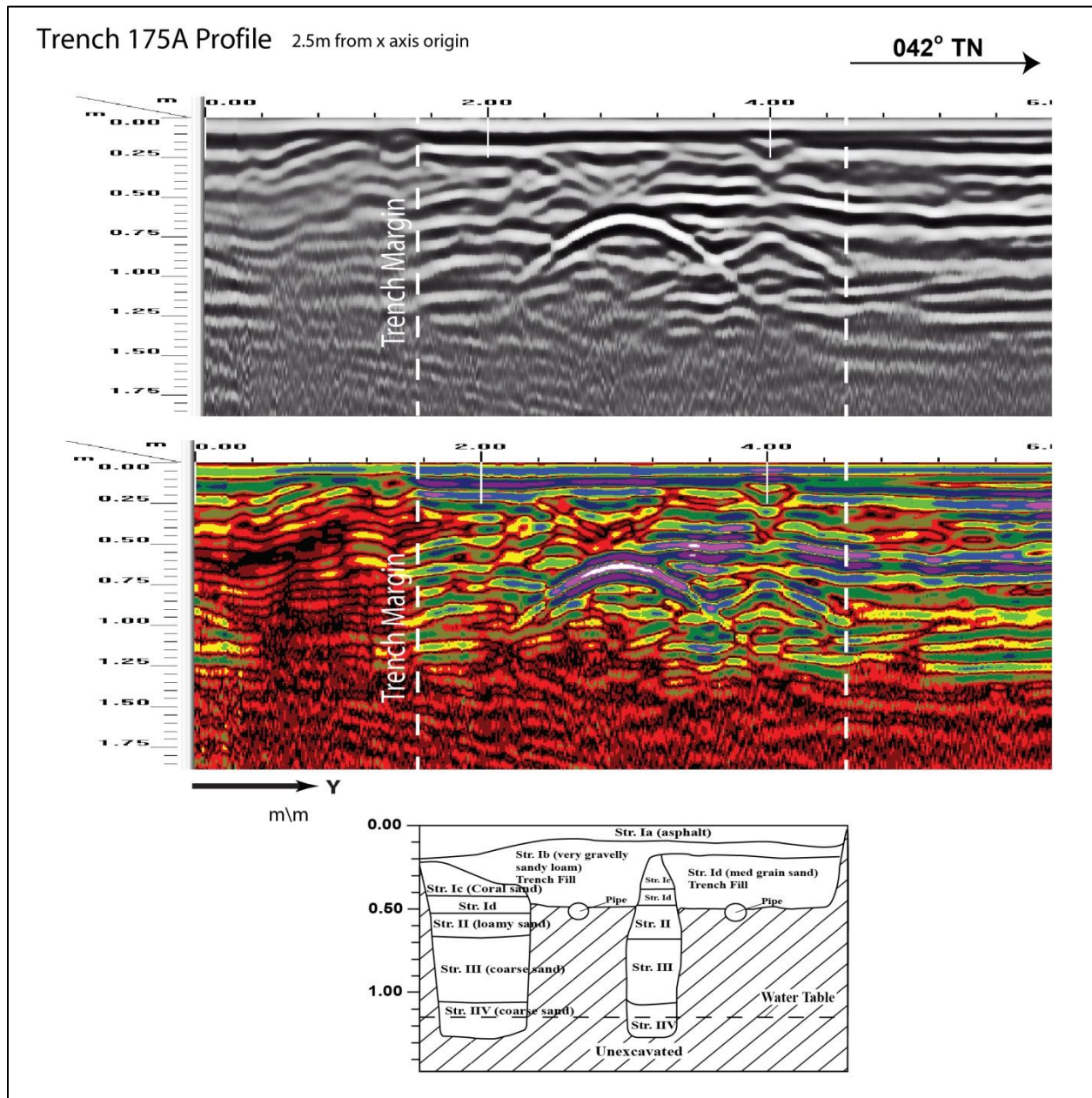


Figure 150. Visual comparison of excavated profile and GPR signal profile of T-175A

Test Excavation 176

T-176 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within an alley along the north side of Office Depot, 95.0 m northwest of Queen Street and Kamakee Street intersection. The GPR grid measured 2.5 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line less than a m northeast. No utilities transected the excavation location.

A review of amplitude slice maps indicated a linear feature but was not encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.5 mbs (Figure 151).

GPR depth profiles for T-176 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 152). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs and again at approximately 0.65 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

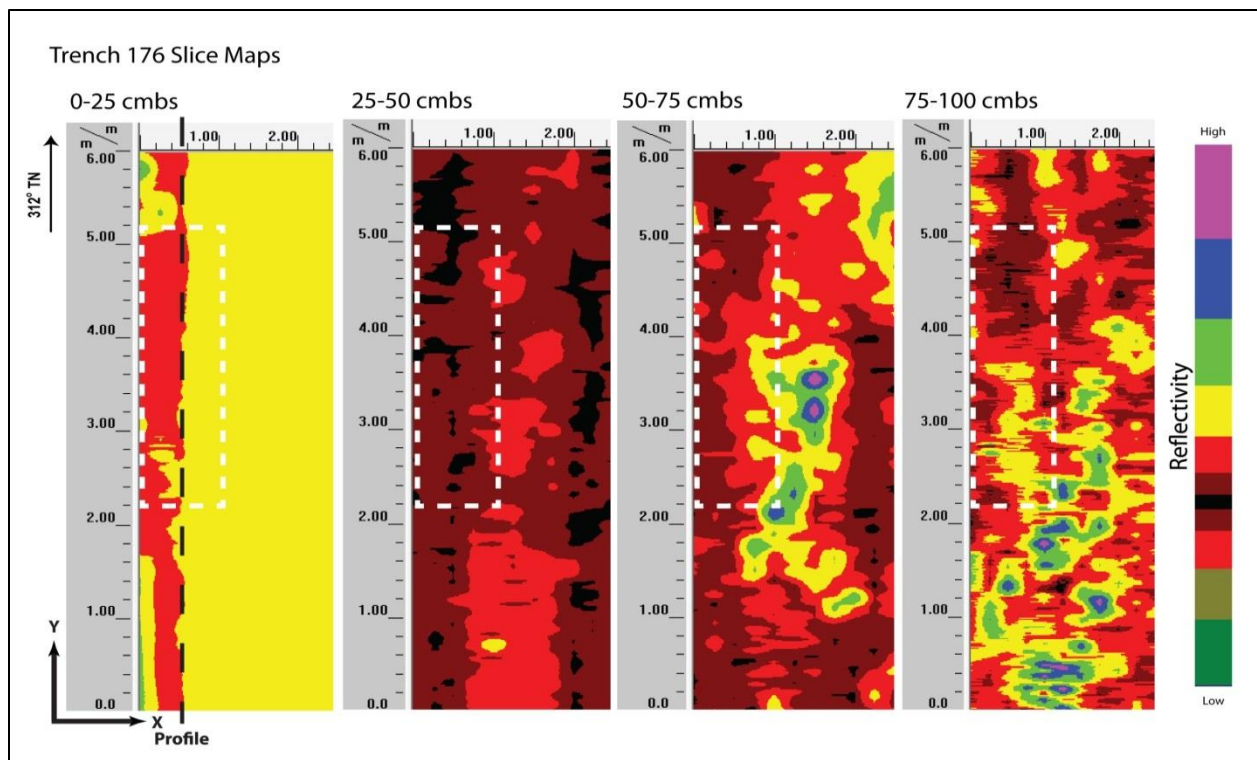


Figure 151. Slice maps of T-176 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 152). Strata Ia to Ib were clearly observed and occurred near the ground-truthed depths. An increase in reflectivity was observed around 0.6 mbs and may represent gravelly cobbly sand or loamy sand. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

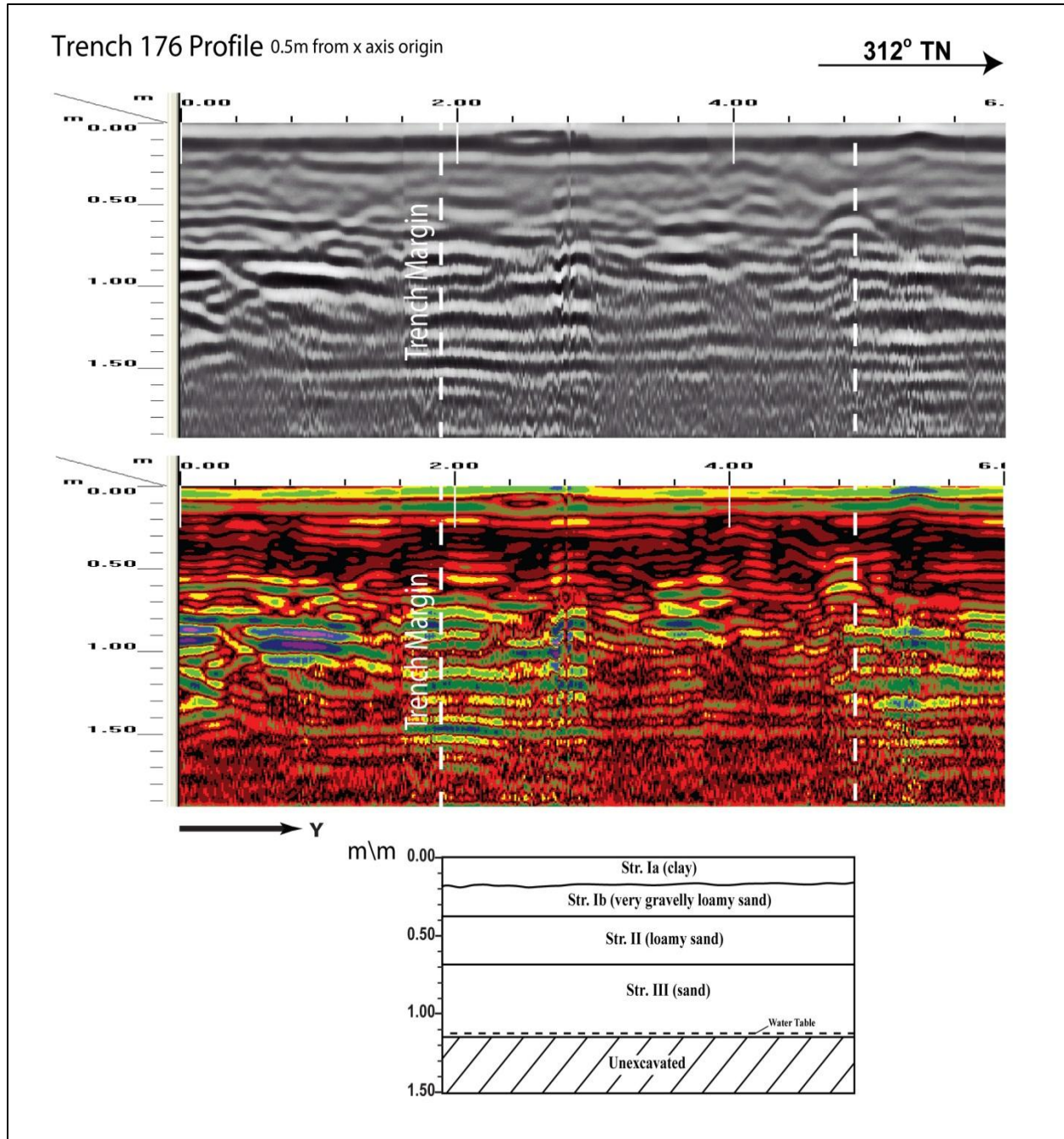


Figure 152. Visual comparison of excavated profile and GPR signal profile of T-176

Test Excavation 177

T-177 measured 0.9 m by 3.0 m and was oriented northeast to southwest and was located within a planter fronting Office Depot, 55.0 m northwest of Queen Street and Kamakee Street intersection. The GPR grid measured 2.0 m by 5.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 4.8 m northeast. A concrete jacket and metal utility pipe were encountered approximately 0.75 mbs in the northeast end of the excavation.

A review of amplitude slice maps indicated linear features but not within excavation boundaries although a concrete jacket and metal utility were encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 153).

GPR depth profiles for T-177 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 154). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs. An anomaly was observed in the profile that corresponded with the concrete jacket and abandoned metal pipe encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

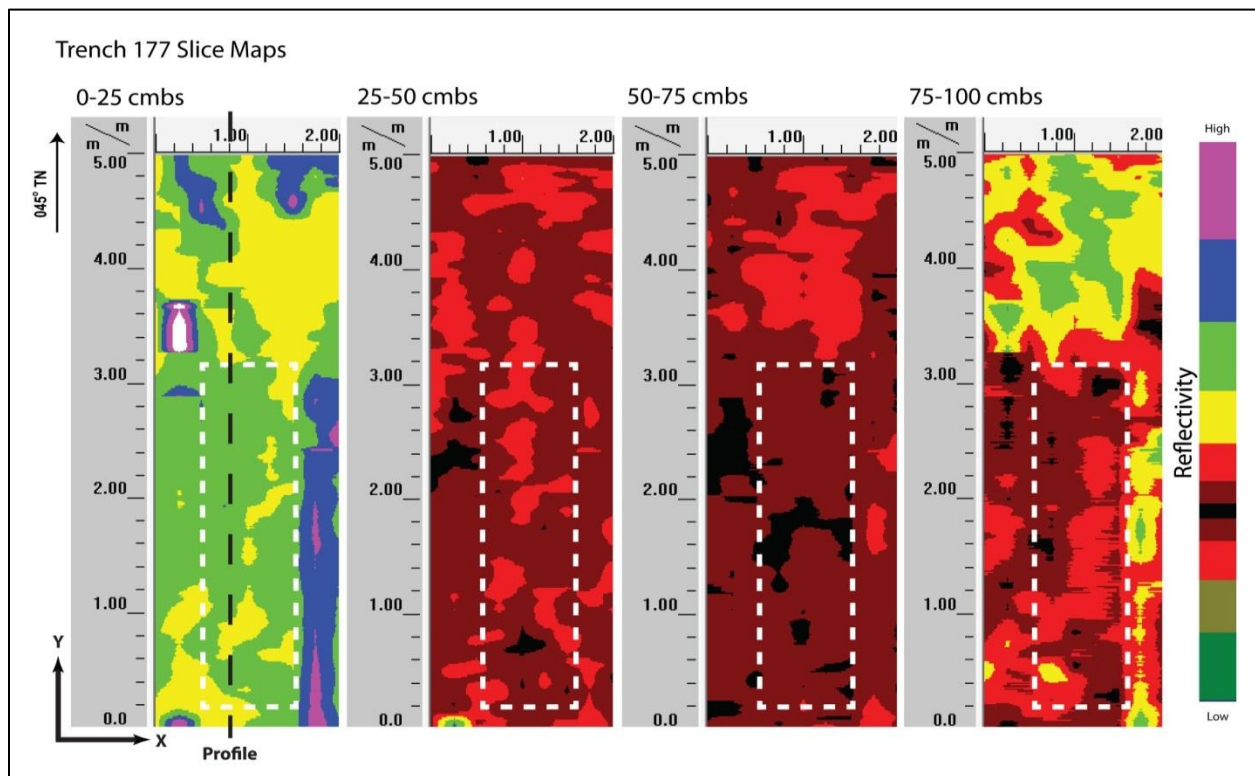


Figure 153. Slice maps of T-177 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 154). Strata Ia to Id were clearly observed and occurred near the ground-truthed depths. All other sediment transitions were below the maximum clean signal return depth. A concrete jacket and metal utility pipe were found 0.75 mbs. These utilities corresponded with an anomaly observed at this location on the profile map. No other discrete objects were observed in the GPR results or subsequent excavation.

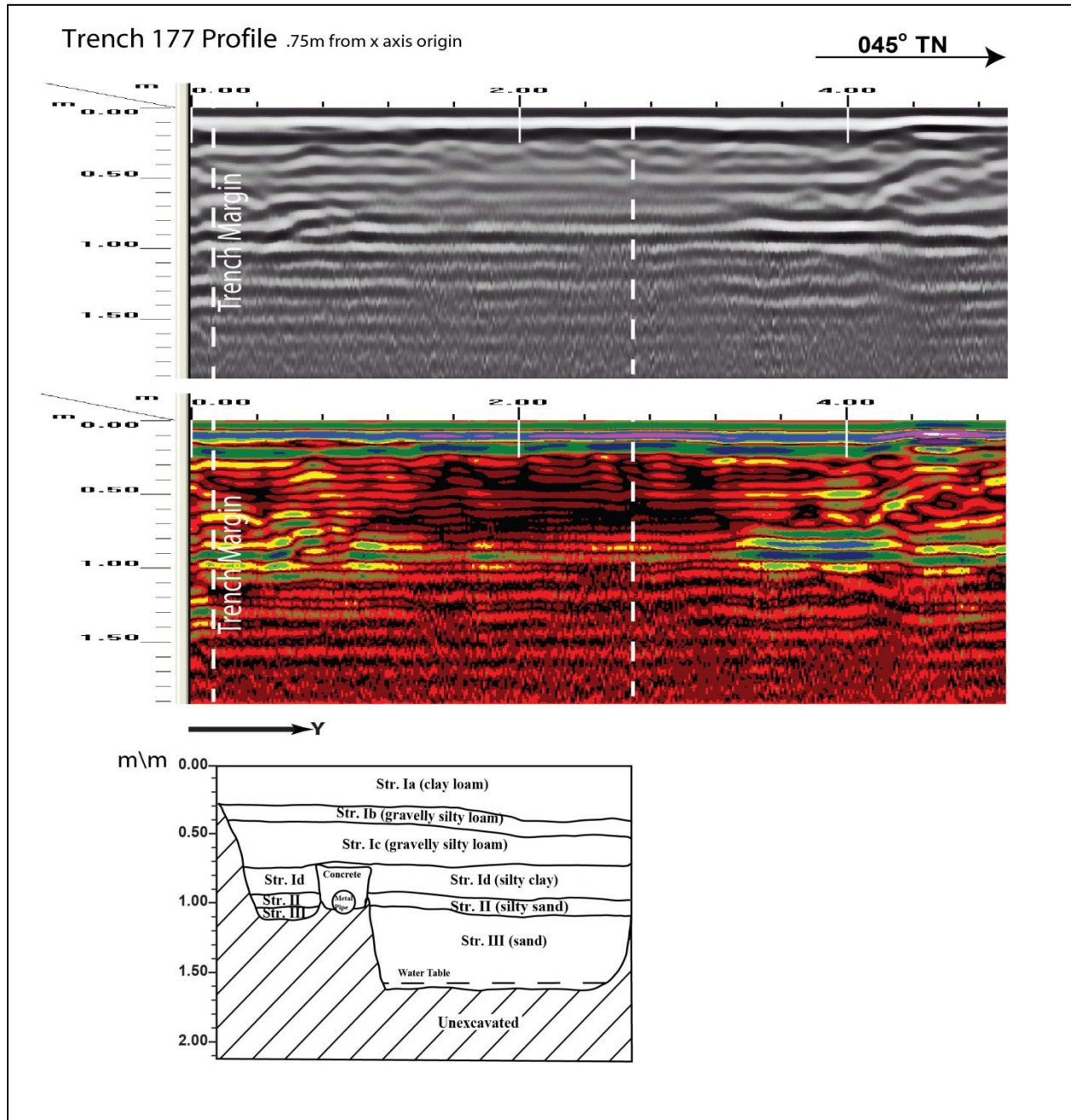


Figure 154. Visual comparison of excavated profile and GPR signal profile of T-177

Test Excavation 178

T-178 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the road cut of Queen Street, 14.0 m northwest of Queen Street and Kamakee Street intersection. The GPR grid measured 2.0 m by 4.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 1.0 m west, water line 1.7 m east. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 155).

GPR depth profiles for T-178 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 156). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

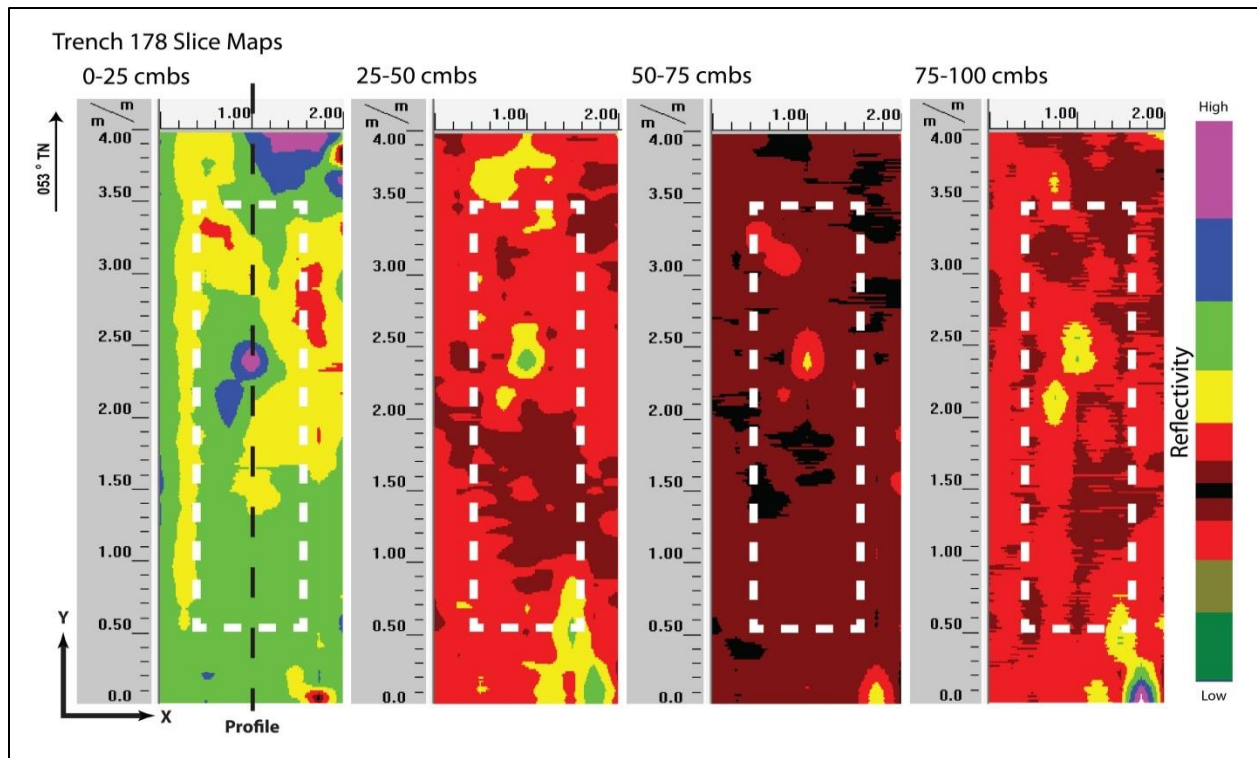


Figure 155. Slice maps of T-178 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 156). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. Strata included a layer of asphalt on top of gravel and followed by 3-B. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

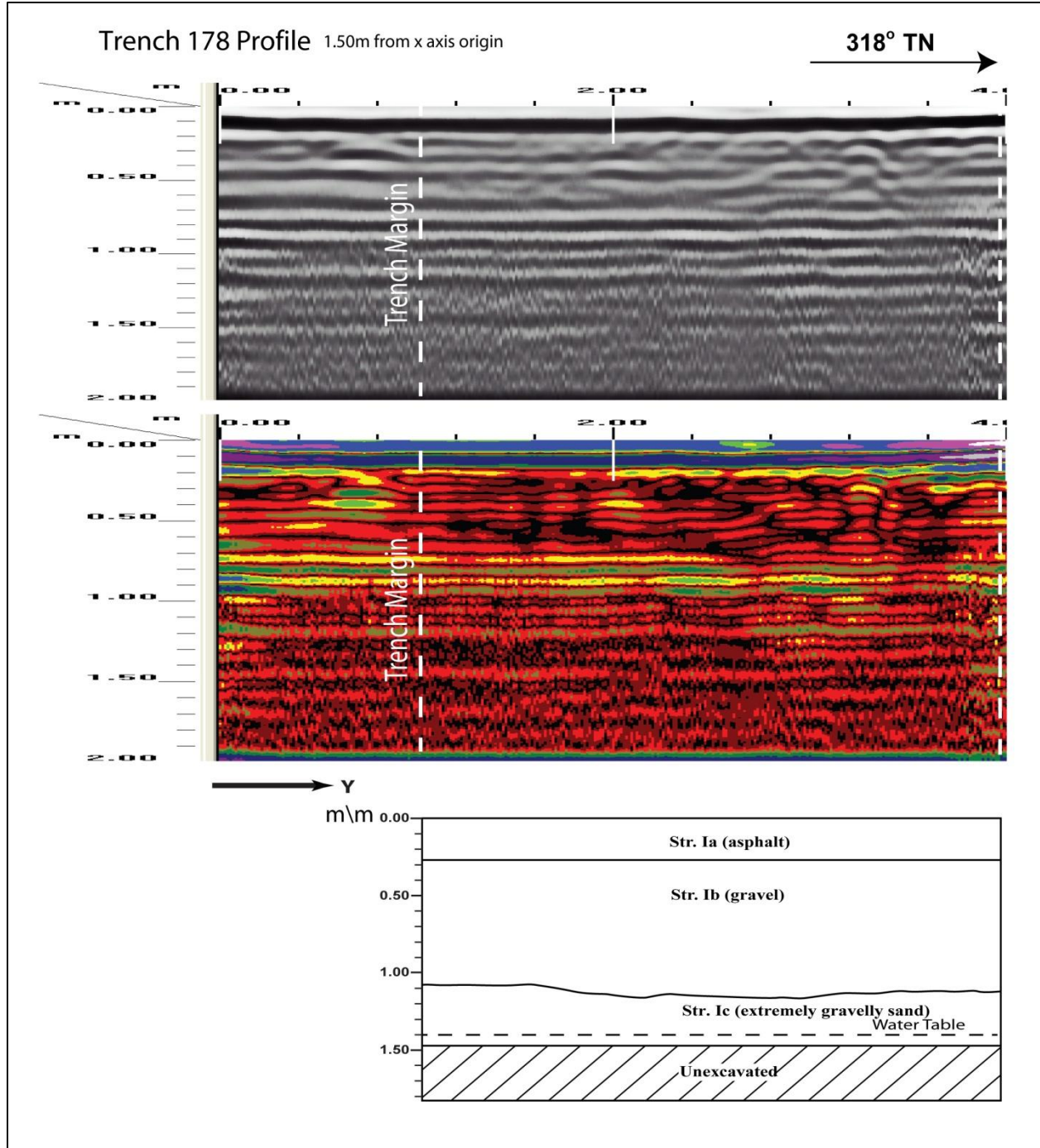


Figure 156. Visual comparison of excavated profile and GPR signal profile of T-178

Test Excavation 178A

T-178A measured 1.0 m by 3.0 m and was oriented northeast to southwest and was located within a grassy median in Office Depot's parking lot, 22.0 m west of Queen Street and Kamakee Street intersection. The GPR grid measured 3.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 8.8 m northeast. Two utility pipes were encountered 0.2 and 0.28 mbs oriented from the center of the excavation through the northeast end and the other along the length of the excavation on the northwest wall, respectively.

A review of amplitude slice maps indicated no linear features although two utilities were encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 157).

GPR depth profiles for T-178A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 158). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. Several anomalies were observed in the profile and could corresponded to the utility along the northwest wall that was encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

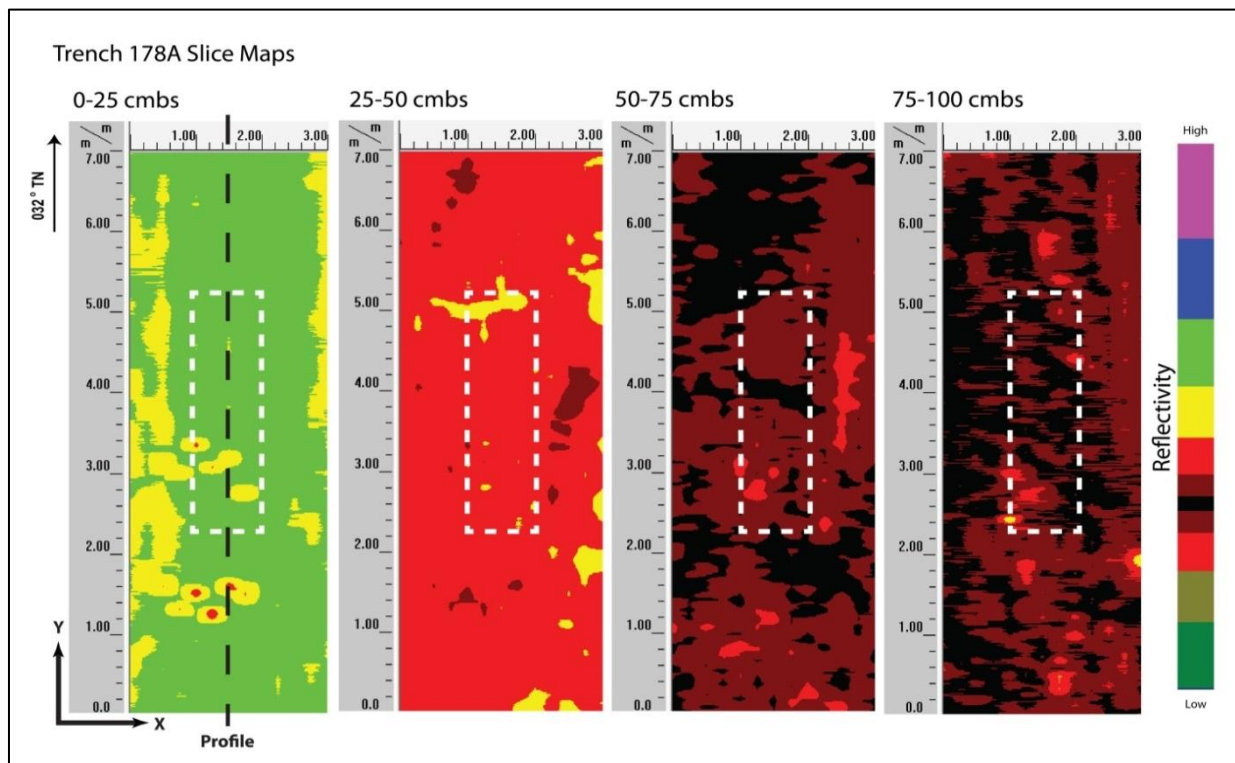


Figure 157. Slice maps of T-178A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 158). Strata Ia to Ic were all clearly observed and occurred near the ground-truthed depths. Two utility pipes were found 0.2 and 0.28 mbs. A void was observed in the profile map and corresponded to the utilities that were found in the same location. No other discrete objects were observed in the GPR results or subsequent excavation.

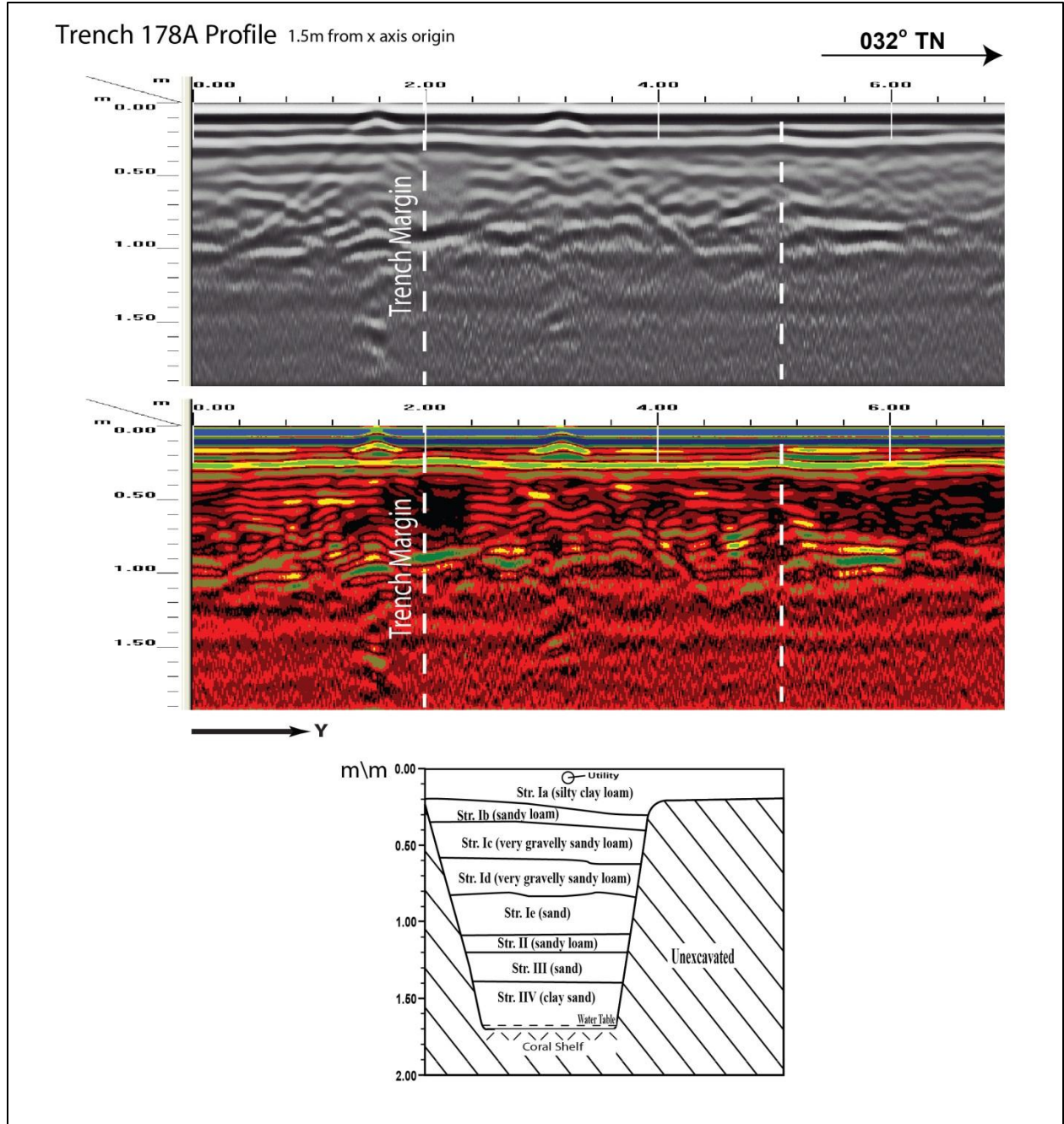


Figure 158. Visual comparison of excavated profile and GPR signal profile of T-178A